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Newfoundland and Labrador Region | **Région de Terre-Neuve-et-Labrador**

An Assessment of Newfoundland and Labrador Snow Crab (*Chionoecetes opilio*) in 2010.

Évaluation du stock de crabes des neiges (*Chionoecetes opilio*) de Terre-Neuve-et-Labrador en 2010

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ABSTRACT

Resource status was evaluated throughout NAFO (Northwest Atlantic Fisheries Organization) Divisions 2HJ3KLNOP4R based on trends in biomass, recruitment and mortality. Multiple indices of these metrics were derived from a suite of data sources that include dockside-monitored landings, harvester logbooks, at-sea observer monitoring, pre-and post-season trawl surveys, broad-scale post-season trap surveys, localized inshore trap surveys, a vessel monitoring system (VMS), and biological sampling data from multiple sources. The resource was assessed separately for offshore and inshore areas of each NAFO division, where appropriate (Div. 3KLP4R). Data availability varied among divisions and between inshore and offshore areas within divisions. The multi-species trawl surveys indicate that the exploitable biomass increased from 2003-2007 due to recovery in the south (Div. 3LNOPs) while the north had decreased (Div. 2HJ3K), and there has been little change since. The trawl surveys indicate that recruitment increased from 2003-2008 and has since changed little. Longer-term recruitment prospects are uncertain, but the spring and fall surveys indicate that there has been a decline in abundance indices of smallest males (<60 mm CW) from 2006-2008 that may indicate reduced biomass in the long-term. Trends in indices are described in detail for each division and conclusions are presented with respect to the anticipated effects of short-term changes in removal levels on fishery induced mortality.

RÉSUMÉ

On a évalué l'état de la ressource dans les divisions 2HJ3KLNOP4R de l'OPANO (Organisation des pêches de l'Atlantique Nord-Ouest) en fonction des tendances relatives à la biomasse, au recrutement et à la mortalité. Les indices multiples de ces paramètres proviennent d'une série de sources de données, notamment des débarquements faisant l'objet d'une surveillance à quai, des journaux de bord des pêcheurs, de la surveillance en mer effectuée par des observateurs, des relevés au chalut avant et après la saison de pêche, des relevés au casier à grande échelle après la saison de pêche, des relevés au casier localisés dans les eaux côtières, du Système de surveillance des navires (SSN) et des données d'échantillonnage biologiques tirées de sources multiples. On a évalué la ressource des zones du large et des zones côtières séparément pour chaque division de l'OPANO, le cas échéant (division 3KLP4R). La disponibilité des données varie en fonction des divisions ainsi qu'en fonction des zones du large et côtières à l'intérieur des divisions. Les relevés plurispécifiques effectués au chalut révèlent qu'entre 2003 et 2007, la biomasse exploitable du sud a augmenté en raison d'un rétablissement (division 3LNOPs), alors qu'on a pu observer une diminution dans celle du nord (division 2HJ3K), et que la situation a peu changé depuis. Les relevés au chalut indiquent également que le recrutement a connu une augmentation entre 2003 et 2008 et qu'il a depuis très peu changé aussi. Les perspectives de recrutement à plus long terme sont incertaines, mais les relevés de printemps et d'automne indiquent un déclin des indices de l'abondance des plus petits mâles (< 60 mm LC) entre 2006 et 2008, ce qui peut annoncer une réduction de la biomasse à long terme. On décrit en détail les tendances relatives aux indices pour chaque division et on présente des conclusions en ce qui concerne les effets prévus qu'auraient des changements à court terme dans les niveaux de prélèvement sur la mortalité par la pêche.

INTRODUCTION

This document serves to assess the status of the snow crab (*Chionoecetes opilio*) resource surrounding Newfoundland and Labrador in NAFO Divisions 2HJ3KLNOP4R. The information presented follows from a formal scientific assessment conducted during February 2011, focused upon determining changes in the exploitable biomass of crabs available to the 2011 fishery (commencing in April 2011), as well as the fisheries of succeeding years.

Snow crab are sexually dimorphic, with males normally achieving larger sizes than females. Exploitable crabs consist of large males that have not molted within the past 6-12 months, as recently molted animals do not yield commercially acceptable meat content. The minimum legal size is 95 mm carapace width (CW); this regulation excludes females from the fishery and ensures a portion of the adult males remain available for reproduction.

Snow crab in Newfoundland and Labrador are part of a larger population in Canadian Atlantic waters, ranging from southern Labrador to the Scotian Shelf (Puebla et al. 2008). However, as movements of individuals within the stock are thought to be limited, assessments are conducted at the NAFO Division level with inshore and offshore areas considered separately where applicable. This is intended to partially conform with crab management areas (CMAs, Fig. 1) while accomodating different types and amounts of available information.

The Newfoundland and Labrador snow crab fishery began in 1967 and was limited to NAFO Divisions 3KL until the mid 1980's. It has since expanded throughout Divisions 2HJ3KLNOP4R and is prosecuted by several fleets. Management of the increasingly diverse fishery led to the development of many quota-controlled areas with about 3200 licence/permit holders under enterprise allocation in 2010. The fishery is prosecuted using conical baited traps set in long-lines. The minimum legal mesh size is 135 mm to allow small crabs to escape. Under-sized and soft-shelled crabs that are captured in traps are returned to the sea and an unknown proportion of those die.

Data from multi-species bottom trawl surveys, conducted during fall in Div. 2HJ3KLNO, spring in Subdiv. 3Ps, and summer in Div. 4R are examined to provide information on trends in biomass, recruitment, production, and mortality over the time series. Multi-species survey indices are compared with other relevant indices derived from data from harvester logbooks, at-sea observers, vessel monitoring system (VMS), the dockside monitoring program (DMP), and inshore and offshore trap surveys, toward inferring changes in resource status for 2011 and beyond.

The snow crab resource declined during the early 1980's but recovered and remained very large throughout the 1990's. The multi-species trawl surveys indicate that the exploitable biomass increased from 2003-2007 due to recovery in the south (Div. 3LNOPs) while the north had decreased (Div. 2HJ3K), and there has been little change since.

METHODOLOGY

MULTI-SPECIES TRAWL SURVEY DATA

Data on total catch numbers and weight were derived from multi-species bottom trawl surveys conducted during fall in Div. 2HJ3KLNO, spring in Subdiv. 3Ps, and summer in Div. 4R. The trawl used in the spring and fall surveys was changed to a Campelen 1800 shrimp trawl in 1995, and this trawl proved to be more efficient in sampling crabs than the previously used groundfish trawl. The fall post-season trawl survey was conducted annually in all divisions except Div. 2H, where it was executed during 1996-1999, 2004, 2006, 2008 and 2010. Snow crab sampling during spring Div. 3LNOPs surveys did not begin until 1999, and data were available from summer trawl surveys conducted in Div. 4R since 2004. The catchability of the survey trawl differs by season; spring (pre-fishery) trawl surveys are considered to be the least reliable because some population components are relatively poorly sampled during spring when mating and molting take place, while the fall trawl surveys are thought to have the highest catchability for snow crabs. Prior to 2009, survey abundance and biomass indices were calculated based on a set of common strata that were sampled in all years for each seasonal survey and NAFO Division. Due to gradual attrition of common strata over time, a set of “core strata” was selected in 2009 and used for the assessment since. This core group included strata most consistently sampled throughout the time series, capturing strata that were common to most years, especially recent years, and does not include inshore strata or deep (>730 m) slope edge strata that have not been regularly sampled. For the summer trawl survey in Div. 4R, all strata occurring within the offshore management area were used to calculate abundance and biomass indices as that survey has suffered less from the attrition of strata over time, although some of the southern strata not considered to represent crab habitat were missed in 2010. The 2006 Div. 3NOPs spring survey was incomplete and has been omitted from analyses. In divisions where both a spring and a fall survey are conducted (Div. 3LNO), only data from fall surveys are used in this assessment.

Snow crab catches from each survey set were sorted, weighed and counted by sex. Catches were sampled in their entirety or sub-sampled by sex. Sampling of individual crabs, of both sexes included determination of carapace width (CW, mm) and (excepting Div. 4R) shell condition. Shell condition was assigned one of four categories: (1) soft-shelled – These crabs had recently molted, have a high water content and are not retained in the fishery; (2) new-shelled - these crabs had molted in spring of the current year, have a low meat yield throughout most of the fishing season, and are generally not retained in the fishery until fall; (3) intermediate-shelled – these crab last molted in the previous year and are fully recruited to the fishery throughout the current fishing season; (4) old-shelled – these crab have been available to the fishery for at least 2 years. Males that undergo their final (terminal) molt in the spring will remain new-shelled throughout the fishing season of that year and will not be fully hardened until the following year. Therefore, new-shelled legal-sized crabs are not considered to be part of the exploitable biomass, in the current year, although it is recognized that some of these males may be retained by the fishery if it extends late into the season. It is assumed that all males with small chelae molt each spring and so remain new-shelled between molts. In reality, however, an annually variable proportion of small-clawed males will not molt in any given year (‘skip molters’) and so will develop ‘older shells’ between molts. For each year that a crab skips a molt, its eventual recruitment is delayed by a year.

Males were also sampled for chela height (CH, 0.1 mm). Males develop enlarged chelae when they undergo their terminal molt, which may occur at any size larger than about 40 mm CW. Therefore only males with small chelae will continue to molt and subsequently recruit to the fishery. A model which separates two 'clouds' of chela height on carapace width data was applied (Dawe et al., 1997) to classify each individual as either adult (large-clawed) versus adolescent or juvenile (small-clawed). This model is defined as:

$$CW = 0.0806CH^{1.1999}$$

Maturity status was determined for females and relative fullness and stage of development of egg clutches were assessed. Occurrence of advanced stages of Bitter Crab Disease (BCD), an assumed to be fatal affliction, was noted in both sexes based on macroscopic examination. In cases of unclear external characteristics, crabs were dissected and classified based on observation of the hemolymph. Observation of cloudy or milky hemolymph supported the classification of such specimens as infected.

We examined annual changes in biomass indices of legal-sized males, by shell condition, toward evaluating the internal consistency of the data series. Males enter the legal-size group as soft-shelled crabs, after the spring molt and remain as new-shelled immediate pre-recruits for the duration of the current year's fishery. They begin to contribute to the legal-sized intermediate-shelled group in the following year. Hence we would expect annual changes in biomass to be first seen in soft or new-shelled legal-sized males and to be followed by similar trends in intermediate and subsequently old-shelled males.

Biomass and abundance indices were calculated from spring and fall surveys using STRAP (Smith and Somerton,1981), to represent the exploitable biomass and pre-recruit biomass. For spring (pre-season) surveys, these indices represent biomass for the immediately upcoming, or on-going, fishery in the current year whereas for summer and fall (post-season) surveys the indices represent biomass for the fishery in the following year. The exploitable biomass index was calculated as the survey biomass index of adult (large-clawed) legal-sized (>94 mm CW) males, regardless of shell condition. Adult males are terminally molted, so that no members of this category would molt in spring and all adults in the fall survey (including new-shelled adults) would be fully recruited to the fishery in the following year. The exploitable biomass index generated from spring survey data includes a component of new-shelled males that would not actually be retained by the fishery in the immediate or upcoming fishery but would be fully recruited to the fishery in the following year. The offshore exploitable biomass for Div. 4R was calculated based strictly on size, as data on shell condition and chela height are not recorded during these summer trawl surveys. Stations within inshore Div. 4R CMAs and CMA 13 (assessed by DFO Quebec Region) were rejected in calculating biomass indices for offshore Div. 4R.

The pre-recruit biomass index was calculated by applying a 19 mm CW growth increment (Hoenig et al., 1994) to all adolescent (small-clawed) males larger than 75 mm CW caught in the surveys, before applying STRAP. The resultant pre-recruit index, from fall surveys, represents a component of legal-sized (>94 mm CW) males that would be recently-molted, (soft or new-shelled), and not recruited to the fishery of the next year, but would begin to recruit (as older-shelled males) in the following year. However, some of these recently-molted males would have remained adolescent, and so would molt one more time before achieving adulthood and subsequently recruiting to the fishery, as intermediate-shelled males, one additional year later (i.e. 3 years after the fall survey year). The pre-recruit biomass index for

Div. 4R was calculated based strictly on size, thus it contains an unknown proportion of sub-legal-sized adult crabs that will never recruit to the fishery.

These exploitable and pre-recruit biomass indices were calculated using the raw survey data. It is known that catchability of crabs by the survey trawl (i.e. trawl efficiency) is lower than 1 and varies with substrate type and crab size (Dawe et al. 2010a). However, trends in raw ('unstandardized') indices are comparable to those in 'standardized' indices (Dawe et al., 2003), that partially account for effects of substrate type and crab size. Projection of biomass indices from the survey year does not account for annual variability in natural mortality or in the proportion of adolescent males that do not molt in the following spring (skip-molters). It is assumed that all small-clawed males molt each year. The spatial distribution of pre-recruit and exploitable biomass was examined using catch rates (numbers per tow) for each survey set.

The ratio of the annual landings to the exploitable biomass index (projected from the fall survey of the previous year) was calculated by NAFO Division to provide an index of exploitation rate. This index overestimates absolute exploitation rate because the survey index underestimates absolute biomass. However, long-term changes in these ratios may be interpreted as reflecting trends in exploitation rate within each Division. It is recognized that annual changes in these ratios may be due to changes in catchability (i.e. trawl efficiency) rather than exploitation rate. However, we feel that long-term trends provide a useful indication of trends in exploitation rates. Inshore commercial catches and data from inshore survey strata in Div. 2HJ3KLNOP were not included in calculating the ratios because inshore survey strata were not surveyed in all years. In Div. 4R, inshore strata have been consistently surveyed in some bays, and the catches from these strata have been removed from offshore indices.

To examine size composition of males, trawl survey catches by carapace width were grouped into 3 mm CW intervals and adjusted to reflect total population abundance indices. In Div. 2HJ3KLNOP, each size interval was partitioned, based on chela allometry, between juveniles plus adolescents (small-clawed) versus adults (large-clawed).

To investigate the possible effect of thermal regime on snow crab production or early survival we compared the exploitable biomass from the trawl survey with lagged (lag of best fit) temperature indices for offshore areas in each of Divisions 2J, 3K, 3L, and Subdivision 3Ps. We used two indices of thermal regime, bottom temperature and area of the Cold Intermediate Layer (CIL). Bottom temperatures used were from shallow strata, on the banks, in each division (<200 m in Div. 2J, <300 m in 3K and <100 m in Div. 3LPs) because settlement of early benthic stages occurs primarily on shallow banks (Dawe and Colbourne, 2002). Mean bottom temperatures for Div. 2J3K were derived using data from fall surveys, whereas those from Div. 3LPs were derived using data from spring surveys. Area of the CIL was the cross-sectional area of the water column occupied by temperatures of <0 °C from oceanographic transects extending across the continental shelf (Colbourne et al. 2011), representing Div. 2J (Hamilton Bank Section) and 3K (Bonavista Section). The CIL index used for the shallow Grand Bank (Div. 3L) and St. Pierre Bank (Subdiv. 3Ps), where the CIL lies directly on the ocean floor, was the percent of bottom habitat covered by water of < 0 °C from the spring multispecies surveys.

FISHERY LOGBOOK DATA

Data on commercial catch (kg) and fishing effort (number of trap hauls) were obtained from vessel logbooks. These data were compiled by the Statistics Division, Policy and Economics Branch, Newfoundland Region of Fisheries and Oceans Canada. Catch per unit of effort (CPUE, kg/trap haul) was calculated by year and NAFO division, and by CMA where applicable. CPUE is used as an index of biomass, but it is unstandardized in that it does not account for variation in fishing practices (eg. soak time and mesh size). Long-term trends in logbook CPUE are presented, as a fishery-based index of trends in biomass, for comparison with other fishery based indices and survey indices.

The number of trap hauls from logbooks was calculated for each Division on a weekly basis to compare the seasonality of the distribution of fishing effort among years, and CPUE was calcuated on a weekly basis to assess fishery performance throughout the season in inshore areas each year. Similarly, weekly CPUEs were compared against the weekly cumulative catch to assess the performance of the fishery against the level of removals in inshore areas each year.

The spatial extent of annual fishing effort for inshore and offshore areas of each NAFO Division was calculated from commercial logbooks. Sets were assigned to 5' x 5' (nautical minutes) cells based on logbook co-ordinates. The annual ratio of the total number of cells with fishing effort (≥1 set) to the total number of cells in each area was used as an index of spatial expansion or contraction and compared with trends in fishery CPUE.

OBSERVER CATCH-EFFORT AND AT-SEA SAMPLING DATA

Set and catch data were available from the Observer Program for the same time series as those from the multispecies surveys (1995-2009), but at-sea sampling data have only been collected since 1999. Levels of sampling are generally highest in offshore Div. 3KLNO due to high observer coverage in those areas (Fig. 2). Sampling has been consistently low in inshore crab management areas and virtually absent throughout Divisions 2H and 4R. The observer set-and-catch database included details about number of traps, landed catch (kg), and discarded catch (kg) for each set observed. An observer-based CPUE index (kg. landed/trap haul) was calculated from the sampled catch for comparison with inshore and offshore logbook CPUE.

For offshore areas, a pre-recruit fishing mortality index (PFMI) was developed based on the ratio of the observed catch rate of pre-recruits discarded in the fishery to the preceding trawl survey biomass index of pre-recruits. This index is defined as;

$$PFMI = S\left(\frac{DPI_t}{PBI_{t-1}}\right)$$

where DPI is the catch rate (kg/trap haul) of measured under-sized and soft-shelled pre-recruits (and under-sized adult males) discarded in the fishery, in year t, calculated from observer sampling data. PBI is an index of the biomass of pre-recruits (and undersized adult males) (t x 1000) from the preceding survey; ie. the fall survey of the previous year for Div. 2HJ3KLNO or the spring survey of the same year for Subdiv. 3Ps. S is a scaling factor to account for incomplete and annually variable levels of observer coverage, defined as:

$$S = \frac{Total\ Landings}{Observed\ Landings}$$

The PFMI overestimates pre-recruit mortality because the PBI underestimates pre-recruit biomass, as a result of low catchability of pre-recruits by the survey trawl. However, we feel that long-term trends in this index provide a useful indication of trends in pre-recruit mortality. In both inshore and offshore areas, the percent discarded (by weight) is viewed as an index of wastage in the fishery. It provides an indication of the level of wastage associated with catching and releasing pre-recruits in the fishery, and is not necessarily proportional to the mortality rate on the pre-recruit population.

Data from biological sampling by observers was also used to quantify the catch components, discarded or retained, in the fishery. Entire trap catches of males were sampled for carapace width (mm) and shell condition. Shell condition categories differed slightly from those used for trawl surveys, in that categories of crabs not recently molted (intermediate-shelled and old-shelled in trawl surveys) were pooled into a single category. These biological sampling data were used to identify specific categories of discards (ie 'undersized' and 'soft' legal-sized). Also, seasonal trends in the percentage of soft-shelled crabs were described. Discarding of recently-molted (especially 'soft') immediate pre-recruits is believed to impose a high mortality on those individuals. A soft-shell protocol was implemented in 2004 to close specific small fishing areas when the percentage of soft-shell crab reached 20%. This was reduced to 15% for offshore Div. 3LNO in 2009 and 2010.

VESSEL MONITORING SYSTEM (VMS) AND DOCKSIDE MONITORING PROGRAM (DMP) DATA

Data on hourly offshore vessel positions from VMS, and landed catch from DMP, were obtained from the Fisheries Management Branch and the Policy and Economics Branch, Statistics Division, Newfoundland Region of Fisheries and Oceans Canada. These datasets were merged based on vessel registration number (VRN), year, month, and day. A CPUE index (kg/fishing hr.) was calculated by year and NAFO Division, as described by Mullowney and Dawe (2009). Fishing hours were screened based on location and speed from hourly positional signals. Signals occurring at 0.1 – 3.0 knot speeds were accepted as fishing signals. The VMS dataset consisted of a short (seven-year) time series and was limited to offshore fishing fleets.

VMS-based CPUE is used as an index of biomass, but it is unstandardized in that it does not account for variation in fishing practices (eg. soak time and vessel drift) (Mullowney and Dawe, 2009). Trends in VMS-based CPUE are presented as a fishery-based index of trends in biomass for offshore areas and compared with commercial logbook and observer-based CPUE indices. CPUE was calcuated on a weekly basis to assess fishery performance throughout the season in offshore areas each year. Similarly, weekly CPUEs were compared against the level of cumulative catch to assess the performance of the fishery in relation to the level of removals in offshore areas each year.

INSHORE TRAP AND TRAWL SURVEYS

Data were available from an inshore Div. 3K trapping survey that was carried out in White Bay and Notre Dame Bay during 1994-2010. There were no surveys in either bay in 2001, and no survey was conducted in Notre Dame Bay in 2009. The survey has consistently occurred in September and occupies 5 of the inshore fall multi-species survey strata (Fig. 3) with a target of 8 sets per stratum. Each set includes 6 traps, with crabs sampled from two large-meshed (commercial, 135 mm) and two small-meshed (27 mm) traps. Catch rate indices (kg/trap haul) of legal-sized males were calculated by shell category (new-shelled recently-molted versus older-shelled), and size distributions were described by claw type (small-clawed juveniles plus adolescents versus large-clawed adults). Mortality was also inferred from levels of BCD observed in these surveys.

Data were also available from two inshore trap and trawl surveys (1979-2009) within Div. 3L and one within Subdiv. 3Ps (2007-2010) (Fig. 3). These surveys were conducted in different seasons; spring (Fortune Bay – 3Ps), summer (Bonavista Bay – 3L), and fall (Conception Bay – 3L). These surveys utilized traps of various mesh sizes for each set, including two small meshed (27 mm) traps. For each survey series, catch rate indices and size distributions were produced as described above for the inshore Div. 3K trapping surveys, and prevalence of BCD was noted. No survey was conducted in Fortune Bay in 2008, and the trawling portion of the survey in 2009 was omitted from analyses due to gear mis-configuration in that year.

POST-SEASON TRAP SURVEY

Data were examined from an industry-DFO Collaborative Post-Season (CPS) trap survey in Div. 2J3KLOPs4R (Fig. 4). These surveys, funded by the Fisheries Science Collaborative Program (FSCP), were examined for the first time in 2006. They were initiated following the 2003 fishery and conducted annually thereafter, beginning Sept. 1st each year. The surveys, conducted by snow crab harvesters accompanied by at-sea observers, focus on commercial fishing grounds within individual CMAs. Survey stations are fixed and generally follow a grid pattern, with maximum station spacing of 5’ X 5’ (Fig. 4). At each station, 6 (inshore) or 10 (offshore) commercial (135 mm mesh) crab traps are set in a fleet. All crab caught are sexed and counted. Biological sampling of male crab is conducted at-sea, by observers, from one trap at each station. Sampling includes determination of carapace width, shell condition, leg loss and presence of BCD. Small-mesh traps are included at selected stations to collect information on pre-recruits and females.

The CPS trap survey is more spatially limited than the multi-species trawl surveys, as it targets only portions of commercial fishing grounds. For analysis of catch rates (numbers per trap), a set of core stations was selected from the survey (Fig. 4) due to incomplete and spatially variable survey coverage each year. Biomass indices derived from this survey were based on a new stratification scheme introduced for this assessment (Fig. 5). In previous years, the multi-species trawl survey stratification scheme was used to derive biomass estimates from the CPS trap survey (Dawe et al., 2011). However, it was abandoned for this assessment due to poor and non-random spatial coverage of the stratification template by the CPS survey. For this assessment, smaller depth-based strata were created to closely conform with all CPS survey stations occupied in inshore or offshore management areas of each division since 2004. The boundary of each stratum extended 5 nm. outside the outermost stations of each survey grid. The set of strata used was common to all years for each zone. Exploitable and pre-recruit biomass indices were calculated from trap survey catch rates using STRAP in a fashion similar to it's application to the multi-species survey data, modifying the program with respect to the area-depth stratification scheme and applying an effective area fished of 0.0053 km² (Dawe et al. 1993), analagous to the area swept by a single trawl survey tow, to extrapolate trap catch rates across the total survey area.

RESULTS AND DISCUSSION

THE FISHERY

The fishery began in Trinity Bay (Management area 6A, Fig.1) in 1967. Initially, crabs were taken as gillnet by-catch but within several years there was a directed trap fishery in inshore areas along the northeast coast of Div. 3KL from spring through fall. Until the early 1980's, the fishery was prosecuted by approximately 50 vessels limited to 800 traps each. In 1981, fishing was restricted to the NAFO division where the licence holder resided. During 1982-1987, there were major declines in the resource in traditional areas of Div. 3K and 3L while new fisheries started in Div. 2J, Subdiv. 3Ps, and offshore Div. 3K. Since the late 1980's, the resource has increased in these areas. Commercial quota allocations for began in Div. 4R in the early 1990's and in Div. 2H in 2008, although there were prior small-scale exploratory fisheries in these areas.

Licences supplemental to groundfishing were issued in Div. 3K and Subdiv. 3Ps in 1985, in Div. 3L in 1987, and in Div. 2J in the early 1990's. Since 1989, there has been a further expansion in the offshore. Temporary permits for inshore vessels <35 ft., introduced in 1995, were converted to licences in 2003 and exploratory licences in the offshore were converted to full-time licences in 2008. There are now several fleet sectors and about 3200 licence holders. In the late 1980's, quota control was initiated in all management areas (Fig. 1) of each division. All fleets have designated trap limits, quotas, trip limits, fishing areas within divisions, and differing seasons. Mandatory use of the electronic vessel monitoring system (VMS) was fully implemented in all offshore fleets in 2004, to ensure compliance with fishing area regulations.

The fishery was traditionally prosecuted during summer and fall but has become earlier in recent years and is now primarily prosecuted during the spring. Late fishing seasons are believed to contribute to a high incidence of soft-shelled immediate pre-recruits in the catch. The fishery was delayed in northern divisions (Div. 2J and 3K) in 2009 due to severe ice conditions. Such severe ice conditions can affect the spatial distribution of fishing effort and fishery performance. The fishery was also delayed, in many areas, in 2010 due to a dispute relating to the price of crab.

Historically, most of the landings have been from Div. 3KL. Landings for Div. 2HJ3KLNOP4R (Table 1, Fig. 6) increased steadily from 1989 to peak at 69,100 t in 1999, largely due to expansion of the fishery to offshore areas. They decreased by 20% to 55,400 t in 2000 and changed little until they decreased to 44,000 t in 2005, primarily due to a sharp decrease in Div. 3K where the TAC was not taken. Landings increased by 22% from 44,000 t in 2005 to 53,500 t in 2009, but then decreased to 52,200 t in 2010, primarily due to a decrease in Div. 3K.

Effort, as indicated by estimated trap hauls, approximately tripled throughout the 1990's (Dawe et al. 2004). It declined in 2000 and increased slightly thereafter. Increasing effort in the 1990's was primarily due to vessels <35 feet with temporary seasonal permits entering into the fishery. Effort has been broadly distributed in recent years (Fig. 7), but there has been a reduction in effort along the shelf slope in Divs. 2J3KNOPs since 2003 (Dawe et al. 2004). Since 2007 there has been little effort along the shelf edge of Div. 3O (Dawe et al. 2009), while effort increased greatly in offshore Div. 3K from 2008 to 2009 (Dawe et al. 2011) and remained high in 2010 (Fig. 7). Effort in inshore areas of Div. 4R has become increasingly contracted and highly aggregated in recent years, and at very low levels in the offshore.

DIVISION 2HJ3KLNOPs

Spatial distribution from fall multi-species surveys (Div. 2HJ3KLNO)

The fall distribution of exploitable males (legal-sized adults, Fig. 8) as well as immediate pre-recruits (> 75 mm adolescents, Fig. 9) throughout NAFO Div. 2HJ3KLNO in 2010 was generally similar to the distribution pattern observed throughout 1997-2009, as previously described (Dawe et al. 2011, Dawe and Colbourne, 2002) with some exceptions. Large males have consistently been virtually absent over a broad area of the shallow (<100m) southern Grand Bank throughout the time series. The abundance of largest males (Fig. 8) has decreased in the northernmost areas (Div. 2J3K) since 2007, while increases occurred in the southernmost areas (Div. 3LNO). Survey catch rates of pre-recruit males (Fig. 9) in 2010 were generally similar to those in 2009, having increased greatly in the southern Divisions (Div. 3LNO) while remaining unchanged in the northern Divisions (Div. 2J3K) since 2007.

Trends in distribution over the 1995-2000 period were reviewed by Dawe et al. (2003) and Dawe and Colbourne (2002). These trends included gradual spatial shifts of highest densities of most size groups, but also sharp annual and area-specific changes in survey catch rates. Such sharp area-specific annual changes in density that occur across both sexes and the entire broad male size range imply spatial and annual variability in catchability by the survey trawl (Dawe and Colbourne, 2002).

Biomass

The spring and fall multi-species trawl surveys indicate that the exploitable biomass declined from the late 1990's to 2003. It increased from 2003-2007 and has since changed little (Fig. 10). The fall post-season surveys in Div. 2J3KLNO indicate that the exploitable biomass was highest during 1996-1998. The more limited time series from spring multi-species surveys in Div. 3LNOPs also indicated a decline in exploitable biomass since the early years of the surveys. The spring and fall surveys both showed decreases in the exploitable biomass indices from 2001 to 2003-2004, with little change until the fall index increased in 2007. Most of the increase was due to recovery in the south (Div, 3LNOPs) while the north (Div. 2HJ3K) has decreased, as reflected in the divisional trends. There has been little change overall in both spring and fall indices over the past 4 years (Fig 10).

Recruitment

Recruitment increased from 2003-2008 and has since changed little. The survey abundance and biomass indices of pre-recruits (Fig. 11) have increased since 2005 due to increases in the south (Div. 3LNOPs). Longer-term recruitment prospects are uncertain but the spring and fall surveys indicate that there had been a decline in abundance indices of smallest males (<40 mm CW) from 2004-2008 that may indicate reduced biomass in the long term (Fig. 12-15). This index for smallest males has increased during the past two years.

We feel there is higher uncertainty associated with the pre-recruit index than with the exploitable biomass index. This difference in uncertainty is not due to differences in precision of estimates but is primarily related to differences in molt status between the two groups. The exploitable biomass index is comprised exclusively of males that were terminally-molted adults in the surveys, whereas the pre-recruit index includes a large component of males that were adolescents as small as 76 mm CW during the surveys. The projection of the pre-recruit index assumes that all those adolescents will molt, survive, grow by 19 mm CW, and subsequently recruit over the following two years, involving yet an additional molt for those that remained legal-sized adolescents, as older-shelled males. In reality, the biomass of new-shelled pre-recruit crabs is greatly affected by annual variability in natural mortality, growth increment, and proportions that fail to molt. These variables currently cannot be predicted and so are not accounted for.

Low bottom temperatures promote terminal molt at small sizes in snow crab, resulting in relatively low recruitment from a given year class (Dawe et al. In press). However, recruitment is more strongly affected by the positive effects of a cold regime on year class production than it is on the negative effects of a cold regime on size-at-terminal molt. Negative relationships between bottom temperature and snow crab CPUE have been demonstrated at lags of 6-10 years (Dawe et al. 2005, 2008) suggesting that cold conditions early in the life history are associated with the production of strong year classes and subsequent strong recruitment. Temperatures on the Newfoundland Shelf were below normal in most years from the mid-1980's to about 1995. These were years of high crab productivity that led to high commercial catch rates during the 1990's. A warm oceanographic regime has persisted over the past decade (Colbourne et al. 2011) implying poor long-term recruitment prospects.

Mortality

Bitter Crab Disease (BCD) has been observed in snow crab, based on macroscopic observations, at generally low levels throughout 1996-2010. The prevalence and distribution of this parasitic disease throughout the Newfoundland-southern Labrador Continental Shelf (Div. 2J3KLNO) has been described in detail by Dawe (2002) and appears related to circulation features along the NL shelf (Dawe et al 2010b).

There had been a broadly-distributed incidence of bitter crab disease during 1996-2006, but the distribution became limited to localized aggregations at low prevalence, primarily in Div. 3K and 3L, in 2007 (Fig. 16). In 2008, BCD prevalence increased in offshore portions of Div. 2J and Div. 3K, but was virtually absent across most of the survey area in 2009. In 2010, there appeared to be a substantial increase in the distribution and prevalence of BCD in offshore Div. 3K. However, this increase has been attributed to technical error and deemed anomalous.

This disease, which is fatal to crabs, primarily occurs in new-shelled crab of both sexes and appears to be acquired during molting (Dawe, 2002). It is unknown how well apparent disease prevalence in trawl-caught samples represents true prevalence in the population, as diagnosis has been based on recognition of external characteristics in chronic cases. It seems likely that our observations underestimate true prevalence. Prevalence levels in the population appear to be directly related to the density of small to intermediate-sized crabs (Mullowney et al. 2011). Therefore, BCD-induced mortality may moderate initially strong year classes before they recruit to the fishery.

DIVISION 2H

The Fishery

There have been exploratory fisheries in Div. 2H since the mid 1990's. A commercial TAC was first established in 2008, and has since been maintained, at 100 t (Table 2, Fig. 17). Landings increased from 70-190 t during 2005-2007 and subsequently declined by 63% to 70 t in 2010. Effort peaked in 2007 and has since declined, although there is uncertainty about the level of effort expenditure during 2010. CPUE decreased from 2006-2009 and was unchanged in 2010, based on the VMS index (Table 2, Fig. 18).

Prior to becoming commercial, the exploratory fisheries in Div. 2H had been concentrated along the shelf edge, east of the Makkovik Bank, as it was during 2007 (Fig. 19). However, in 2008 there was a shift with much of the effort occurring west of the Makkovik Bank and closer to shore in the southern portion of the division. This near-shore area was most commonly fished in 2009, but in 2010 the effort was re-distributed throughout the Division. There is a high degree of uncertainty in the distribution of effort throughout Div. 2H due to a low rate of logbook returns, especially in 2010, with only 14% of logbooks returned.

The fishery has predominately occurred during June and July since 2006 (Fig. 20). The low level of logbook returns in 2010 is reflected in the temporal distribution of recorded fishing effort, with data available from only one week, whereas quota monitoring reports show the fishery ran from late June to mid August in 2010.

Biomass

The logbook CPUE index is considered unreliable due to inadequate data resulting from the low rate of logbook returns, especially in 2010. The VMS CPUE index decreased from 2006-2009 and was unchanged in 2010. The emergence of the fishing area west of the Makkovik Bank yielded high catch rates of 16-20 kg/trap in 2008 (Fig. 21), but CPUE has since decreased in that area. The re-distribution of effort from west of the Makkovik Bank in 2010 is consistent with the deterioration of catch rates in this area.

Weekly catch rates have been highly variable in this fishery each year (Fig. 22); however, there is a tendency for CPUE to peak near the mid to late fishing season in most years. These peak catch rates occurred after about 40 – 90 t of removals in most years (Fig. 22). In 2010, catch rates were highest in the early part of the season and, except for an anomalous decrease during week 19, declined only marginally for the remainder of the fishery.

The exploitable biomass changed little between 2008 and 2010. The post-season trawl survey exploitable biomass index peaked in 2006, decreased by 68% to 2008, and remained unchanged in 2010 (Table 3, Fig. 23). The majority of exploitable-sized crabs in the trawl survey since 2004 have been captured in the extreme southeast portion of the Division near the slope to the east of Makkovik Bank (Fig. 24). The catches of exploitable crabs in this area have dissipated since 2006.

Production

Recruitment

Recruitment has decreased since 2004 and is expected to be low over the next several years. We examined annual changes in biomass indices of legal-sized males from fall multi-species surveys, by shell condition (Fig. 25), toward evaluating the internal consistency of the data series. Males enter the legal-size group, after the spring molt, as soft-shelled crabs and they begin to contribute to the legal intermediate-shelled group in the following year. From 2004-2008, new-shelled crabs dominated the legal-sized population component. However, in 2010 the catch was almost wholly intermediate-shelled. This suggests recruitment into the legal-sized component of the population (as new-shelled crabs) has recently decreased.

Size compositions from fall multi-species surveys (Fig. 26) show a clear pattern of modal progression between 2004 and 2006, as adolescent pre-recruits in 2004 recruited to adults in to the exploitable biomass by 2006 and subsequently became depleted with virtually no small crabs evident in 2008 or 2010. The majority of pre-recruit crabs captured in the trawl survey have been taken from a similar area as the exploitable crabs, to the east of the Makkovik Bank (Fig. 24), with catch rates dissipating since 2004. There were no pre-recruit males captured in the 2010 post-season trawl survey (Table 3, Fig. 27). Therefore, short-term recruitment is expected to be low.

Mortality

Data are insufficient to calculate annual values for the exploitation rate index due to the biennial frequency of the survey. A pre-recruit fishing mortality rate index cannot be calculated due to the absence of observer data.

DIVISION 2J

The Fishery

Landings (Table 4, Fig. 28) peaked in 1999 at 5,400 t, decreased sharply to 3,700 t in 2000 and changed little to 2002, before declining to 2005. They increased by 60% from 1,500 t in 2005 to 2,400 t in 2008 and then decreased by 14% to 2,100 t in 2010. Effort increased from 2000 to a record high level in 2002-04. It decreased sharply in 2005 and further declined slightly to 2008. It increased by 27% in 2009 and changed little in 2010. Commercial catch rate (CPUE) has oscillated over the time series (Table 4, Fig. 29), initially decreasing from 1991-1995, and increasing to a peak in 1998. It declined steadily by 76% from 1998 to a record low level in 2004. It increased from 2004-2007 and changed little until it decreased sharply in 2010.

The 2010 fishery was concentrated in Hawke and Cartwright channels (Fig. 30), as it was in the previous three years. In 2007-2010 there was limited fishing on the shelf edge relative to previous years.

The 2010 fishery began in early May and ran for a total of fourteen weeks, with most effort expended by the beginning of August (Fig. 31). Relative to 2007-09, the 2010 fishery began early. This may be attributable to the ice-free conditions off the Labrador Coast during the spring of 2010.

Biomass

Commercial CPUE has oscillated over the time series and is currently in a decreasing phase (Fig. 29). The commercial logbook, observer, and VMS CPUE indices all increased from 2004-2007. However the observer and VMS indices declined in 2008 while logbook CPUE increased. All CPUE indices declined during the past two years. Differences between CPUE indices could be related to a greater contribution by small vessels to the logbook datasets than to the other datasets. VMS is exclusive to larger vessels, and observer coverage is generally higher on larger vessels. The decreases in fishery performance over the past few years have been most common in the southern portion of the Division, in and around the Hawke Channel (Fig. 32), while the northern area of fishing in and around the Cartwright Channel has maintained greater consistency.

The spatial coverage of the fishery has been inversely related to commercial CPUE (Fig. 33). The percentage of available 5' x 5' cells occupied by the fishery declined abruptly from its highest level of 19% in 2004 to its lowest level of 8% in 2006 and has been variable since. The inverse relationship between spatial coverage of the fishery and commercial CPUE could be a function of harvester searching behaviour. It is likely that some fishers will search for new or alternate fishing grounds when catch rates are low or in decline. Conversely, when catch rates are high, there would be little need to search for alternate fishing grounds. However, in Division 2J the annual distribution of ice coverage could also influence the spatial distribution of fishing, such as in 2009, when the spatial index increased sharply during a heavy ice year.

Weekly trends in VMS CPUE showed distinct late-season spikes during 2006-09 (Fig. 34). However, in 2010 no late-season increase in CPUE occurred, and a pattern of decreasing catch rates throughout the season was evident. After about 500 t of removals, the 2010 fishery performed much more poorly than did the 2009 fishery, with a generally increasing trend in catch rate in 2009 opposed by a decreasing trend in 2010 (Fig. 34).

Size distributions from at-sea sampling by observers (Fig. 35) showed decreasing catch rates of legal-sized males from 1999-2004 (Dawe et al. 2010c), reflecting the trend in CPUE. Modal CW increased from about 92 mm in 2004 to about 101mm in 2005, and subsequently to 110 mm in 2008 with an overall increase in abundance of legal-sized animals, reflecting an increase in the exploitable biomass as members of a recruitment pulse molted and grew to large sizes. The primary mode remained at 110mm in 2009, but abundance of most sizes was marginally lower than in 2008. In 2010, the primary mode retreated to 98 mm CW and the abundance of crabs decreased across the entire size range. Meanwhile, most of the catch was dominated by old-shelled animals for the first time since 2006.

The increase in observer catch rate of legal-sized males in 2006 was due to an increase in catch rate of old-shelled crabs (Fig 36). The further increase in catch rate in 2007-2008 was due to a sharp increase in new-hard-shelled crabs, while the catch rate of old-shelled crabs decreased sharply. This suggests some inconsistency in shell condition classification because an increase in abundance of old-shelled crabs should be preceded by an increase in new-hard-shelled crabs. In 2009, catch rates of both new and old-hard shelled legal-sized crabs decreased. This would not be expected, as catch rates of old-hard shelled crabs should have increased in 2009, following the increase in catch rate of new-hard shelled crab in 2007 and 2008. Shell condition classification is highly subjective and the 3-stage scale used by observers (since 2000) is one that combines the intermediate-shell stage (of the 4-stage scale used during surveys) with the old-shell stage. The sharp increase in old-shelled crabs in 2010 is consistent with the high levels of new-shelled catch in 2008-09, perhaps indicating some improvement in observer shell classification in recent years. When the new-hard and old-shelled categories from at-sea sampling are pooled, their combined catch rate agrees well with observed CPUE for most of the time series (Fig. 36). The reasons for the relatively large differences between the two indices in 2008-09 are unknown.

The exploitable biomass has decreased in recent years. The post-season trawl survey exploitable biomass index decreased steadily by 92%, from 1998-02 (Table 5, Fig. 37). It increased from 2002 to peak in 2006 but remained below pre-2002 levels. It has since declined to 2009 and changed little in 2010. The capture of exploitable crabs by the trawl survey has been almost exclusive to the Hawke and Cartwright Channels since 2007 (Fig. 38), although the largest catch rate occurred atop the Hamilton Bank in 2010.
The post-season trap survey index declined sharply from 2007-09 and changed little in 2010. However, that index reflects only the southern portion of the division. The increase in the fall survey exploitable biomass index from 2002-2006, was small relative to the increase in CPUE indices (Fig. 29). This likely reflects effects of recent management changes in the fishery on fishery performance (CPUE) as described earlier. The CPS trap survey catch rates of legal-sized crabs decreased markedly from 2007-2009 (Fig. 39), with the decline first occurring in new-shelled crabs in 2008, and subsequently in old-shelled crabs in 2009. The marginal overall increase in 2010 was attributable to an increase in catch rates of legal-sized old-shelled crabs. This is consistent with catch rates of legal-sized males in the trawl survey (Fig. 40), which showed a marginal decrease in new-shelled crabs and a marginal increase in old-shelled crabs in 2010.

Effect of ocean climate variability

For most of the short sixteen-year time series, the exploitable biomass has been generally inversely related to bottom temperature atop the Hamilton Bank in Div. 2J at a seven-year lag (Fig. 41). Similarly, the exploitable biomass has been generally positively related to the area of the cold intermediate layer (CIL) in Div. 2J at a seven year lag. The generally increasing trend of temperature and relatively low area of the CIL in recent years (despite high annual variability) implies reduced production or early survival in recent years and subsequent low levels of recruitment in the near future.

Production

Recruitment

Recruitment has recently declined as reflected by the decline in exploitable biomass between 2006 and 2009 (Fig. 37) while landings changed little (Fig. 28). Males enter the legal-size group as soft-shelled crabs, after the spring molt, and they begin to contribute to the legal intermediate-shelled group in the following year. Trends in the biomass index by shell condition reflect this process, in that the biomass of new-hard-shelled males peaked in 1997-98 whereas that of intermediate-shelled males peaked in 1998-99 (Fig. 40). The biomass index of new-hard-shelled males dropped sharply in 1999, whereas biomass of intermediate-shelled crabs declined steadily during 2000-02. The biomass of new-hard-shelled crabs increased steadily from 2002-06 while the biomass of older-shelled crabs remained low**.** This suggests that the fishery has been highly dependent upon immediate recruitment, which has been gradually declining since 2006.

The size compositions from the post-season trap survey (Fig. 42) show a decrease in catch rate throughout most of the size range of sub-legal and legal-sized crabs from 2007-2009; most prominent in new-shelled males. There was little change in the catch rate of most sizes of crabs in 2010, although the proportion of old-shelled crabs in the catch increased. The size compositions from fall multi-species surveys (Fig. 43) are examined with the abundance index (ordinate) truncated for smallest males (<50 mm CW), so as to focus on trends in abundance for larger males. The survey data indicate that most of the relatively abundant sub-legal-sized adolescent males evident in 2004 achieved legal size in 2005-2007, and the abundance of most sizes of legal-sized crabs has since declined. The size distributions (Fig. 43) suggest that abundance indices of smallest males (<50 mm CW) decreased from 2001-2004 and have generally remained low since, except for a brief increase from 2007-08. The modal group of 75-92 mm CW pre-recruits in 2004 that progressed into the exploitable biomass during 2005-2010 may have been derived from the large modal group of smallest (<50 mm CW) males in 2001, but there has been no clear evidence of modal progression over the time series. Therefore, long-term recruitment prospects are uncertain. However, generally low abundance of smallest males since 2004, together with the persistence of a warm oceanographic regime (Fig. 41), may suggest relatively poor long-term recruitment prospects.

The catch rates of total discards decreased substantially between 2004 and 2006 and have since varied without trend (Fig. 44). The recent variability reflects trends in the catch rate of soft-shelled legal-sized crabs, with catch rate of undersized crabs varying without trend since 2006. High catch rates of soft-shelled crabs in the fishery did not agree with low catch rates in the post-season trawl survey during 2002-2005 (Fig. 40), implying high handling mortality in those years. However low observed fishery catch rates of soft-shelled crabs in recent years (2008-2010) do agree with those observed in both the post-season trap (Fig. 39) and trawl (Fig. 40) surveys.

Recruitment is expected to remain low in the short term. The fall survey pre-recruit index decreased sharply in 1999 (Table 5, Fig. 45). It was exceptionally high in 2004 and has otherwise fluctuated without trend since 1999. The capture of pre-recruit males in the trawl survey has been almost exclusive to the Hawke and Cartwright Channels since 2007 (Fig. 38). The post-season trap survey index has changed little over its limited time series (Fig. 45).

Reproduction

The percentage of mature females carrying full clutches of viable eggs (Fig. 46) has varied over the time series, but consistently remained above 75%, including in the four most recent years. It is unknown to what extent changes in fecundity affect subsequent abundance of settling megalopae. The number of mature females captured in the trawl survey has remained low since 2005.

Mortality

Exploitation

The exploitation rate index declined from 2003-2007 but has since gradually increased (Fig. 47). Maintaining the current level of fishery removals would likely have little effect on the exploitation rate in 2011.

Indirect fishing mortality

The pre-recruit fishing mortality index declined sharply from 2003-05, and has since remained low (Fig. 47). The percentage of the total catch discarded (Fig. 47) increased from 2001 to a record high level in 2004. It then declined sharply to 2006, implying reduced wastage of under-sized and new-shelled pre-recruits in the fishery. It has since remained relatively low, varying without trend.

Snow crabs that are caught and released as under-sized or legal-sized soft-shelled males in the fishery are subject to multiple stresses and have unknown survival rates. Time out of water, air temperature, water temperature and shell hardness all influence the mortality level on discarded snow crab (Miller, 1977). Other environmental factors such as wind speed, sunlight and size of the crab may also influence survivability (Dufour et al. 1997). Poor handling practices such as prolonged exposure on deck, dropping or throwing crab, as well as inducing limb loss cause increased mortality levels associated with catching and discarding crabs. Recently-molted (soft-shelled) snow crab are subject to more damage and mortality than hard-shelled crab (Miller 1977; Dufour et al. 1997). The relatively low level of soft-shelled discards in the fishery since 2005 (Fig. 44) implies little wastage of immediate pre-recruit crabs in the 2006-10 fisheries. This is reflected in the low values of soft-shell prevalence in most weeks of the fishery in recent years (Fig. 48). However, there is a suggestion of seasonality to the prevalence of soft-shelled crabs in the catch, with prevalence generally increasing throughout July. Therefore, it is likely that the earlier fishing seasons in recent years (Fig. 31) have contributed to the reduced levels of fishery-induced mortality.

An area of Hawke Channel has been closed to all fisheries except snow crab from 2003 to 2009 (“Hawke Box” - Fig. 30). CPUE has trended similarly inside and outside the closed area since its inception (Fig. 49). This implies that other fisheries that do not target snow crab do not represent a major source of snow crab mortality. A recent study on the effectiveness of this closed area concluded that the Hawke Box has failed to protect pre-recruit crabs largely due to an intensification of the crab fishery inside of it in the years surrounding closure, with high discard rates of soft-shell crab in the order of 50-75% of the catch during 2002-2004 having a long term impact upon the productivity of the Hawke Channel (Mullowney et al. 2012).

Natural Mortality (BCD)

BCD occurs almost exclusively in recently-molted crabs (Dawe 2002; Mullowney et al. 2011). BCD in Div. 2J males (Fig. 50) has been most prevalent in small new-shelled crabs of 40-59 mm CW. Prevalence, in new-shelled crabs, has generally been low in this area, usually about 2-3 percent occurrence for that size range, excepting 1999 and 2008, when 18% and 16% of new-shelled adolescents in that size group were visibly infected. BCD has been virtually absent from Div. 2J from 2006-2010 with the exception a large spike in 40-59mm CW adults in 2008.

DIVISION 3K OFFSHORE

The Fishery

Landings peaked in 1999 at 17,900 t (Table 6, Fig. 51). They decreased to about 13,000 t in 2000-04, due to a reduction in the TAC. They decreased sharply in 2005 when the TAC was not fully subscribed because the fishery was closed prematurely due to high levels of soft-shelled crabs in the catch (Dawe et al. 2006). Landings more than doubled from 6,000 t in 2005 to 12,600 t in 2009 but decreased by 23% to 9,600 t in 2010 (13% below the TAC). Meanwhile effort changed little until it increased by 70% in 2009 before decreasing by 15% in 2010. Commercial CPUE (Table 6, Fig. 52) indicates substantial deterioration of fishery performance in recent years. CPUE indices increased sharply from 2005 to record high levels in 2007 (VMS index) or 2008 (logbook and observer indices). All three indices agree that CPUE has declined sharply since 2008.

There have been notable changes in the distribution of the Division 3K offshore fishery in the past two years (Fig. 53). The effort has intensified throughout the offshore, with the most distinctive increases occurring in the northwest portion of the Division, in and around the St. Anthony Basin, and throughout the Funk Island Deep in the central portion of the Division. The great increase in offshore fishing effort in 2009 may have been partly due to severe ice conditions early in the fishery and grid closures due to application of the soft-shelled protocol, which altered the spatial distribution of effort and adversely affected fishery performance. These factors may have also contributed to the spatial expansion of fishing effort evident in 2009, and extension to depths greater than those usually fished.

The temporal distribution of the 2010 fishery was similar to the 2007 and 2008 fisheries, with most effort expended from late April through early July (Fig. 54). The delayed 2009 fishery reflects unfavourable ice conditions in that year (Dawe et al. 2011).

Biomass

The deterioration of fishery performance over the past two years has occurred throughout Division 3K offshore (Fig. 55). However, the greatest decreases have occurred in and around the Funk Island Deep, extending along the western portion of the Funk Island Bank. The spatial coverage of the fishery has been inversely related to commercial CPUE since 1995 (Fig. 56). The percentage of available 5’ x 5’ cells occupied by the fishery increased abruptly in 2009, exceeding 40% for the first time since 2004, and was virtually unchanged in 2010.

VMS-based CPUE was lower throughout the season in 2009 than during the previous two years (Fig. 57). Initial CPUE in 2010 was similar to late-season CPUE in 2009; the catch rates remained relatively consistent until week 8, at about 4000 t of removals, and then declined steadily throughout the remainder of the season. Catch rates during the last 5 weeks of the season were much lower than those of the previous 4 years.

Size distributions from at-sea sampling by observers (Fig. 58) show that modal CW has not changed since 2004. Observed catch rates of legal-sized new-hard-shelled crabs have changed little since 2000, with the exception of a distinct increase in 2008 (Fig. 59). The observed catch rates of legal-sized old-shelled crabs were unchanged from 2000-2005 before increasing to a peak in 2007 (Fig. 59). They have since declined steadily. Similar to Division 2J, the inconsistency in the timing of peaks for new-hard and old-shelled crabs, with old-shelled crabs peaking before new-shelled crabs, suggests some inconsistency in the classification of shell conditions by Observers. When combined, trends in catch rates of new-hard and old-shelled legal-sized crabs have agreed well with observed CPUE since 1999 (Fig. 59).

The exploitable biomass, as indicated by the post-season trap and trawl survey indices, declined by about half since 2008 (Table 7, Fig. 60). The post-season trawl survey exploitable biomass index decreased from its highest level in the late 1990's to its lowest in 2003, before increasing to 2007. The post-season trap survey exploitable biomass index increased in 2006. Both indices remained high to 2008 and decreased sharply to 2010. The pattern of distribution of exploitable crabs captured in the trawl survey has changed little since 2007 (Fig. 61), concentrated in the central portions of the offshore and extending north-south throughout the entire region. However, the magnitude of catches has been reduced considerably in the past two years, with reduced catch rates throughout the offshore (Fig. 61). Trends in biomass indices by shell category disagree between the post-season surveys. For example, the catch rate of new-shelled crabs declined from 1996-1999 in the trap survey (Fig. 62) but the biomass index increased from 1996-1998 in the trawl survey (Fig. 63). However, both surveys showed a marked decrease in the indices of new-shelled legal-sized males in 2009. These indices remained low in both surveys in 2010, suggesting continued low recruitment for 2011.

Effect of ocean climate variability

The exploitable biomass in Div. 3K offshore has generally been inversely related to bottom temperature on the Funk Island Bank, at a 7-year lag (Fig. 64). Similarly, there has been a general positive relationship between the exploitable biomass index and the spatial extent of the CIL at a 7-year lag (Fig. 64). However, the increased biomass indices in 2007-2008 were not associated with an increase in CIL area. Nevertheless, high (although variable) temperatures and very low CIL area in recent years (Fig. 64) imply continued poor recruitment prospects for the foreseeable future.

Production

Recruitment

Recruitment decreased in 2010, as reflected by the sharp decrease in the post-season exploitable biomass indices while landings also decreased**.** Recruitment is expected to change little in 2010 and prospects remain poor in the short-term. This is reflected by the low level of new-shelled legal-sized crabs in both post-season surveys (Fig. 62-63), which changed little in 2010 following a sharp decline in 2009. The recent decrease in recruitment was likely exacerbated by a high handling mortality on soft-shelled immediate pre-recruits, particularly during the 2009 fishery. This handling effect may have been partially mitigated in the 2010 fishery by reduced fishing effort, particularly late in the season.

Size distributions from the CPS survey (Fig. 65) showed no change in modal size since 2005, remaining at 110 mm CW. Catch rates decreased across most sizes for both new-hard-shelled and old-shelled crabs in 2009. There was little change in catch rates by size or shell condition in 2010, implying little change in recent recruitment.

A group of adolescent males with modal CW of 65 mm in 2004 and about 77 mm in 2005 was evident from small-meshed traps (Fig. 66). These adolescents were likely responsible for the elevated biomass in 2007 and 2008. Catch rates of adolescents larger than about 65 mm CW decreased greatly from 2005-2008 and have since remained low, implying poor recruitment prospects. A group of very small adolescents (<60 mm CW) appeared in 2007 (Fig. 66), but their presence (as larger crabs) has not been detected since. Such lack of trends may be related to very limited spatial coverage by small-meshed traps..

Size frequencies from the post-season trawl survey (Fig. 67) are generally consistent with the CPS trap survey, in showing a clear decrease across the entire size range in 2009 (Fig. 65) and little change for most sizes in 2010. Both surveys show very low catch rates of adolescents larger than about 65 mm CW in 2010 (Fig. 66-67). A substantial portion of a modal group of adolescents at about 40-60 mm CW in 2006 and 50-80 mm CW in 2007 terminally molted in 2008 (Fig. 67). This likely contributed further to the reduction in recruitment potential for 2010-11. Longer-term recruitment prospects are uncertain. However, relatively low abundance of smallest males (<60 mm CW) in both surveys since 2003-04 (Fig. 66-67), together with the persistence of a warm oceanographic regime (Fig. 64), suggest relatively poor recruitment prospects in the long term.

The observed catch rate of under-sized crabs in the fishery has changed little since at-sea sampling began in 1999 (Fig. 68) but have been marginally lower since 2005. Lowest soft-shelled incidence during 2006-2008 has been associated with the highest exploitable biomass indices in recent years (Fig. 60). By contrast, peaks in soft-shelled crab incidence, in 2004-2005 and 2009 are generally associated with low biomass indices, highlighting concern that the fishery may impose a high handling mortality on soft-shelled crabs when the exploitable biomass is low.

Post-season pre-recruit biomass indices from trap and trawl surveys fluctuated without trend during 2005-2008 (Fig. 69) and have declined by 34 and 52% respectively since 2008 (Table 7, Fig. 69). The reduction in pre-recruit biomass in the trawl survey has occurred throughout the offshore during the past two years (Fig. 61), with an especially large reduction in catch rates in the southeastern portion of the Division in 2010.

Reproduction

The percentage of mature females carrying full clutches of viable eggs (Fig. 70) has exceeded 75% in most years, including the past four.

Mortality

Exploitation

The trawl survey exploitation rate index declined sharply from 2006-2009 and has since increased back to the 2006 level (Fig. 71). Maintaining the current level of fishery removals would likely result in an increase in the exploitation rate and high mortality on soft-shelled immediate pre-recruits in 2011.

Indirect fishing mortality

The pre-recruit fishing mortality index (Fig. 71) increased from 2006-09 and changed little in 2010.

The percentage of the total catch discarded in the fishery (Fig. 71) declined markedly between 2004 and 2006 and continued to decline to its lowest value in 2008. It increased sharply in 2009, primarily due to a high incidence of soft-shelled immediate pre-recruits in the fishery (Fig. 68). This implies an increase in wastage of under-sized and, in particular, soft-shelled pre-recruits in the fishery in 2009. It decreased slightly in 2010, consistent with the decrease in observed catch rates of both soft-shelled and undersized crabs (Fig. 68), implying a slight reduction in handling of pre-recruits. However, these reductions in handling of soft-shelled pre-recruits were exclusive to the early and mid portions of the 2010 fishery. Soft-shell catch rates have generally increased around mid June in recent years (Fig. 72), likely reflecting seasonality in timing of molting. The delayed fisheries of the past few years, relative to 2006, have meant that the period of potentially fishing on high levels of soft-shell crab has been prolonged. In 2010, soft-shelled prevalence first reached 20% in week 12, and gradually increased for the duration of the season. A high level of spatiotemporal variability in observer coverage creates considerable uncertainty regarding true levels and trends in the incidence of soft-shell crabs, but catch rates of soft-shelled crabs were clearly higher in 2010 than in 2009 throughout weeks 9-15 (Fig. 72). The incidence of soft-shelled crab was about 20% throughout the last month of the 2010 fishery, implying a high handling mortality on soft-shelled crabs as the season prolonged.

A portion of the Funk Island Deep in the south of Div. 3K offshore (Fig. 53) was closed to gillnet fisheries in 2002 and has been closed to all fisheries except snow crab during 2005-2010. CPUE increased both inside and outside of the closed area from 2005-2008, before decreasing in 2009 (Fig. 73). The decrease in CPUE in 2009 was particularly substantial inside the closed area, which is likely related to the large increase in snow crab fishing effort inside the exclusion area (Fig. 53). CPUE remained low both inside and outside the Funk Island Deep in 2010 (Fig. 73).

Natural Mortality (BCD)

Prevalence of BCD, from multi-species trawl samples (Fig. 74), has overall been higher in this division than in any other division, with maximum levels during 1996-1998, and 2008, in the order of 8% in 40-75 mm CW new-shelled males. The high 2010 values are thought to be anomalous due to technician error. Annual trends in BCD prevalence (across all sizes) were similar to those in the survey biomass indices, especially for pre-recruits (Fig. 69), featuring highest values in 1996-1998, a sharp drop to minimum levels in 1999, generally lower levels during 2000-2007, and an increase in 2008. This is consistent with a density-dependent effect on prevalence (Mullowney et al. 2011). The very low prevalence levels, across all sizes for both adolescents and adults in 1999 and 2003 (Fig. 74) coincides with anomalously low survey biomass indices, especially for pre-recruits (Fig. 69). If those anomalously low biomass indices are due to low trawl efficiency, as believed, then this implies that infected crabs have a higher catchability by the survey trawl than healthy crabs.

DIVISION 3K INSHORE

The Fishery

Inshore landings (Table 6, Fig. 75) peaked in 1999 at 3,500 t and decreased sharply in 2000 due to a TAC reduction. They increased to 3,300 t in 2003, changed little in 2004, and decreased by 21% in 2005. Landings increased by 33% from 2,700 t in 2005 to 3,600 t, in 2009, but dropped by 22% to 2,800 t in 2010 (16% below the TAC). Effort declined from 2004 to 2008 and increased by 67% since 2008. Commercial CPUE (Table 6, Fig. 76) indicates substantial deterioration of fishery performance over the past two years.

With limited room for spatial expansion in most CMAs, the fishing pattern has remained relatively consistent in recent years (Fig. 54-55). However, there have been some subtle changes in the pattern of fishing in recent years, including an expansion of effort in Notre Dame Bay (CMA 3D) in the past two years and increased effort in the extreme northern portion of CMA 3A in 2010 (Fig. 54-55). The temporal distribution of the fishery has been relatively constant for the past three years, with most effort expended from late April to late June (Fig. 77).

Biomass

CPUE increased sharply from 2005 to a record high level in 2008, but has since declined by half (Table 6, Fig. 76). A high level of bias created by temporal inconsistency in the distribution of observer coverage among CMAs (Fig. 78) creates uncertainty in observer-based CPUE at the divisional level and does not allow for interpretation of observer CPUE in some CMAs (Fig. 79). In recent years, the highest numbers of observed sets have occurred in CMA 3C (Green Bay), whereas CMA 3D (Notre Dame Bay) received high levels of observer coverage from 2004-2005, but lower levels since (Fig. 78). The remaining CMAs have consistently received low levels of observer coverage.

The spatial coverage of the fishery has been inversely related to commercial CPUE from 1996-2010 (Fig. 80). The area fished decreased from about 40-45% of available cells in 2004-05, to about 30% of cells occupied during 2006-08. In recent years, the areal extent of the fishery has been increasing, to about 35% of the grounds occupied in 2010. This recent increase in spatial coverage has been opposed by a rapid decrease in CPUE.

CPUE indices show a pattern of depletion throughout the season in all years. Trends in weekly commercial CPUE (Fig. 81) indicated that the fishery has performed more poorly throughout the season in 2010 than it did in 2008-09. Trends in CPUE in relation to cumulative catch (Fig. 81) showed that initial CPUE in 2010 was comparable to that of 2006-07 and 2009, but decreased more quickly, and at about 400 t of removals began to diverge from the better performing 2009 fishery. After about 1,200 t of removals, CPUE remained below 5 kg/trap for the duration of the 2010 season.

The exploitable biomass, as indicated by the post-season trap survey index, decreased gradually between 2007 and 2010 (Fig. 82) but there was considerable variability among management areas. The low 2009 index is believed to be an anomaly due to low capture efficiency of traps in some areas during the 2009 survey. The catch rate of legal-sized crabs in the post-season CPS trap survey decreased markedly for both new-shelled and old-shelled crabs in 2009 (Fig. 83). However, both shell categories increased in 2010. The effect of low capture efficiency in 2009 can be seen across all sizes of legal-sized crabs in the CPS trap survey (Fig. 84).

Production

Recruitment

Recruitment prospects, as indicated by the post-season trap survey index, have improved slightly, but there is considerable variability among management areas. The CPS pre-recruit biomass index of undersized crabs decreased steadily from 2006-2008 but then increased in 2010 (Fig. 85). The 2009 index is believed to be an underestimate due to low capture efficiency of traps in some areas during the 2009 survey. However, the 2010 index does remain above the 2008 level, implying improved prospects in the short-term. Similar to legal-sized crabs, the low capture efficiency is evident across all sizes of sub-legal-sized crabs in 2009 (Fig. 84). Longer term recruitment prospects are uncertain.

Mortality

Exploitation

It was not possible to estimate the exploitation rate index in 2010 because of uncertainty concerning the 2009 exploitable biomass index. Data are insufficient to estimate a pre-recruit fishing mortality index.

Indirect fishing mortality

Spatiotemporal inconsistencies in the distribution of observer coverage do not allow for a reliable index of discards at the divisional level.

Natural Mortality (BCD)

BCD prevalence has been monitored by DFO trap surveys in White Bay and Notre Dame Bay (Fig. 86) since 1994. BCD has consistently occurred at much higher prevalence levels in these inshore Div. 3K trap survey samples (Fig. 87-90) than in the predominately offshore Div. 3K Campelen trawl samples (Fig. 74). This likely reflects differences in catchability of diseased animals between traps and trawls (based on comparative trap/trawl sampling), but it may also, in part, reflect higher prevalence in inshore than offshore areas. In White Bay, prevalence has been periodic, with two distinct pulses of infection over the time series (Fig. 87). Peaks in prevalence have occurred in successively deeper strata at one to two year time lags. BCD prevalence patterns in White Bay are thought to reflect the relative abundance of small to mid-sized adolescents, and the time lag effect across strata likely reflects migration of crabs to deeper waters over time (Mullowney et al. 2011). In 2009-10, BCD prevalence in all three White Bay strata was low, which likely indicates that the most recent pulse of adolescents has progressed through the most susceptible size range. This is also apparent on a size-specific analysis for adolescents and adults, with all groups of crabs showing low BCD prevalence in all strata in 2009-10 (Fig. 88). In Notre Dame Bay, there have been two pulses of infection as well (Fig. 89), but no clear difference in timing between strata as in White Bay. Prevalence originally peaked in 1996, and most recently in 2004-2006. Interestingly, from 2006-2008, prevalence was highest in large adolescents in shallow stratum 611, as opposed to smaller adolescents in deeper stratum 610 (Fig. 90). Notre Dame Bay was not surveyed in 2009 due to inclement weather.

Spatial variability - Trends by CMA

CMA 3A (Canada Bay)

In the north, in CMA 3A (Canada Bay) (Fig. 1), CPUE recently peaked at a historical high in 2008 but has declined sharply in the past two years (Fig. 79). This is consistent with CPUE trends throughout most of the inshore (Fig. 76) and offshore (Fig. 52) of Div. 3K.

CMA 3B (White Bay)

Commercial CPUE most recently peaked in 2004, and with the exception of 2009, has decreased each year since (Fig. 79). The 67% decrease in CPUE in 2010 was the largest single-season decline in the history of the White Bay fishery. The CPS trap survey catch rates of legal-sized crabs declined abruptly in 2009 (Fig. 91), preceding the abrupt 2010 fishery CPUE decline. However, catch rates of both new-shelled and old-shelled legal-sized crabs increased in the CPS survey in 2010 (Fig. 91), consistent with trends in new-shelled legal-sized crabs in the deep commercial strata (613-614) of the DFO trap survey (Fig. 92). This may indicate an increase in the exploitable biomass available for the 2011 fishery but there is tremendous uncertainty due to the unknown extent of catchability effects in the 2009 surveys. The White Bay fishery has become heavily reliant upon immediate recruitment. This is evident in both the CPS and DFO trap surveys, which show the majority of the catch is comprised of new-shelled crabs (Fig. 91-92). The heavy reliance on immediate recruitment in the fishery each year is a concern with respect to soft-shelled crab, especially if the fishery becomes prolonged. The increased catch rates of new-shelled legal-sized crabs in both surveys should contribute to an increased biomass for 2011. Longer-term recruitment prospects are uncertain due to the anomalously low catch rates in large-meshed traps in the CPS survey in 2009 (Fig. 93) and small-meshed traps in the DFO survey in 2010 (Fig. 94).

CMA 3BC (Outer Green Bay / Notre Dame White Bay)

Commercial CPUE has been highly variable since 1990 (Fig. 79). CPUE was at its highest in 2008, decreased by half in 2009, and marginally decreased further in 2010 (Fig. 79). CPUE trends are generally consistent with the adjacent offshore area (Fig. 52).

CMA 3C (Green Bay)

CPUE in Green Bay has oscillated since the late 1980s, and observer CPUE trends have agreed with logbook CPUE trends when observer data were sufficient (Fig. 79). The large decrease in fishery CPUE in 2009 was followed by a marginal further decrease in 2010. Observer sampling shows a greater decrease in catch rates in 2010, almost wholly attributable to decreased catch rates of old-shelled legal-sized crabs (Fig. 95). Observer size frequencies show that the catch has been dominated by old-shelled crabs for the past three years, with the abundance of most sizes of legal-sized crabs becoming successively depleted each season (Fig. 96), especially at largest sizes. This is consistent with catch rates of legal-sized old-shelled crabs in the CPS survey (Fig. 97). Recruitment is expected to change little in the short term, as indicated by little change in new-shelled legal-sized crabs in both observer (Fig. 95) and CPS survey (Fig. 97) indices. Longer-term recruitment prospects are uncertain, but both large-meshed (Fig. 98) and small-meshed (Fig. 99) traps in the CPS survey show most of the under-sized crabs captured in the past four years are small adults, which would imply reduced recruitment potential going forward. Total discards in the fishery have been gradually increasing since 2007 (Fig. 100), and a sharp increase in the percentage discarded in 2010 (Fig. 100) was associated with an increased incidence of soft-shelled crabs in the catch (Fig. 101). This implies increased wastage in the 2010 fishery, with fishing occurring on levels of soft-shell approximating 20% from mid June to late July.

CMA 3D (Notre Dame Bay)

Fishery CPUE peaked at a record high level in 2008 before decreasing sharply in 2009, consistent by both logbook and observer indices (Fig. 79). There is uncertainty in the 2010 CPUE due to opposing trends in the two indices. Observer sampling showed a marginal increase in catch rates of old-shelled legal-sized crabs in 2010 (Fig. 102), most apparent at largest sizes (Fig. 103). The small increase in catch rates of legal-sized crabs in the observer data is consistent with a slight increase in the catch rates of legal-sized crabs in the CPS survey (Fig. 104), occurring after the fishery. However, the increase in the CPS survey was attributable to increases in both the new-shelled and old-shelled components of the catch. There was no DFO trap survey in 2009 to compare with trends in the CPS survey, but both surveys are consistent in showing a large decrease in the exploitable biomass since 2007 (Fig. 104-105), most apparent in the deep (commercial) stratum of the bay. The fishery has become increasingly dependant upon immediate recruitment since 2006, as seen by an increasing proportion of legal-sized crabs that are new-shelled in the CPS survey (Fig. 106). Short-term recruitment prospects remain poor relative to 2006-2008 levels. Longer-term prospects are uncertain, but small-meshed traps in the DFO survey have captured fewer under-sized adolescent males in the past two years than in the preceding three years (Fig. 107). Fishery-induced mortality caused by discarding has been relatively low since 2005 (Fig. 108), although a small increase in the percentage of the catch discarded in 2010 appears attributable to a small increase in the incidence of soft-shelled crabs in the catch (Fig. 108-109).

DIVISION 3LNO OFFSHORE

The Fishery

Landings, mostly in Div. 3L, peaked at 27,300 t in 1999 and decreased to about 22,100 t in 2000 due to a reduction in the TAC (Table 8, Fig. 110). Landings remained at 22,000-25,000 t since 2000. Effort increased steadily from 2000-2008 and has since declined by 16%. Commercial CPUE (Table 8, Fig. 111) indicates that fishery performance has recently improved. CPUE declined from 2000-2008, to the lowest level since 1991, but has increased during the past two years. The logbook CPUE series is considered unreliable in this area due to a high degree of inaccurate reporting.

Since 2007, most of the effort has been expended across the northern face of the Grand Bank and along the Div. 3N slope edge (Fig. 112). There have been some minor changes in the distribution of fishing in recent years, such as a reduction in effort in the extreme northern portion of the Division along the Div. 3KL line, the emergence of a pocket of effort in the centre portion of the Grand Bank to the northeast of the Whale Deep, and an increase in effort inside of the Whale Deep area of Div. 3O. The 2010 fishery was delayed relative to the 2009 fishery, most closely reflecting the temporal distribution of the 2008 fishery (Fig. 113), which was delayed due to ice conditions. In 2010, most effort occurred from early May to late August. It is unknown to what degree the price dispute in 2010 may have impacted the Div. 3LNO fishery.

Biomass

From 2005-2009, the greatest reductions in fishery performance occurred in the northeast portion of the Division (Fig. 114), with the remainder of the Division performing more similarly from year to year. Generally, the western and southern portions of the division have performed at a high level in recent years and the Div. 3N slope edge has performed at a lower level. In 2010, increases in CPUE occurred throughout the division, with the fishery performance improving mostly across the northern face of the Grand Bank, with high catch rates extending further west than during 2005-2006. Not all areas improved in 2010 however, as CPUE in the Whale Deep decreased and CPUE along the Div. 3N slope edge was similar to the preceding years. The spatial coverage of the fishery has been inversely related to commercial CPUE since 1999 (Fig. 115). The percentage of available 5’ x 5’ cells occupied by the fishery increased from 2006-09 as CPUE declined. The sharp increase in CPUE in 2010 was opposed by a sharp decrease in areal extent of the fishery.

VMS-based CPUE was most greatly improved in the middle of the 2010 fishery season relative to 2009 (Fig. 116). In 2009, CPUE declined from week 1 to week 8 and improved thereafter. In 2010, initial CPUE was similar to the late-season CPUE of 2009, and catch rates improved in mid-season. The divergence in fishery performance trends between 2009 and 2010 occurred from about 5,000 to 12,000 t of removals (Fig. 116).

Size distributions from at-sea sampling by observers remained platykurtic from 2004-07, with little change in shape and a primary mode at 110mm CW (Fig. 117). During this time, a reduction in catch rates occurred for all sizes of legal-sized crabs. In 2008, there was a dramatic change in the size distribution, with the primary mode shifting to about 92-98mm CW. This modal shift coincided with an increase in the magnitude of catch rates for crabs from about 80-98mm CW, likely indicating the entry of a recruitment pulse into legal size. Since then, the mode has remained centred at 98mm CW and the catch rates of crabs of about 89-113mm CW, have increased, indicative of the continued progression of a recruitment pulse into the exploitable population. Observer sampling data indicate that the 2010 increase in CPUE was largely due to an increase in new-shelled legal-sized crabs (Fig. 118). An initial small increase in new-shelled legal-sized crabs in 2009 was followed by a marginal increase in old-shelled crabs in 2010, thus it is likely there will be an increase in legal-sized old-shelled crabs in the population in 2011. The tight association of CPUE from the sampled catch (new-shelled plus old-shelled) with set and catch based CPUE estimates indicates there has been little wastage of the resource in Div. 3LNO since 1999.

The exploitable biomass has recently increased. Both the trap and trawl survey exploitable biomass indices increased sharply in 2009 (Table 9, Fig. 119). The trap survey index increased further in 2010, while the trawl survey index decreased. However, both indices remain above 2005-2008 levels. The greatest increases in catch rates of exploitable crabs in the trawl survey have occurred in the northern portion of the Division in the past two years (Fig. 120). The CPS trap survey catch rates of new-shelled legal-sized crabs increased in 2008-09, which was followed by an increase in catch rates of old-shelled legal-sized crabs in 2010 (Fig. 121). The catch rates of new-shelled legal-sized crabs were unchanged in 2010, at a high level relative to 2004-08. The catch composition of exploitable crabs in the trawl survey was similar, with catch rates of new-shelled crabs increasing from 2007-2009, and intermediate-shelled crabs increasing during the past two years (Fig. 122). The catch rate of new-shelled crabs decreased in 2010. However, as in the CPS survey, it remained high relative to the levels of the mid 2000s.

Effect of ocean climate variability

The negative relationship of bottom temperature in Div. 3L with future exploitable biomass has not been as strong as in Div. 2J3K. The relationship, with temperature lagged by eight years, is poor prior to about 2002, after which the expected inverse relationship between the two indices improves (Fig. 123). The lack of fit prior to 2002 could in part be due to the lower levels of harvest occurring on the population of crabs before that time (Fig. 110). Similarly, there is a lack of fit in the expected positive relationship between lagged spatial coverage of <0°C water atop the Grand Bank and future exploitable biomass prior to 1999, after which the relationship holds (Fig. 123). The generally high temperatures and low spatial coverage of cold water atop the Grand Bank in recent years implies relatively poor recruitment potential for the near future.

Production

Recruitment

Both post-season surveys indicate that recruitment has been recently increasing and prospects remain promising for the next two to three years. The recent recruitment increase is reflected by the recent increases in new-shelled legal-sized crabs in both post-season surveys (Fig. 121-122). Observer sampling also showed an increase in new-shelled legal-sized crabs during 2010 (Fig. 118).

Size distributions from the CPS trap survey showed a large increase in catch rates of crabs on both sides of the 95mm CW legal-size line during the past three years (Fig. 124), reflecting the increasing recruitment. Similar to the observer size frequencies (Fig. 117), the CPS trap survey size frequencies showed degradation in the catch rates of most sizes of legal-sized crabs from 2004-07, since followed by an increase in small legal-sized and sub-legal-sized males. The Div. 3LNO fishery is not as heavily dependant upon immediate recruitment each year as in some other areas, as seen by higher proportions of old-shelled crabs in the observer and CPS size frequency distributions (Fig. 117, 124) than in most areas of 2J3K. Small-mesh trap size frequency distributions from the CPS survey distinctly show the progression of a modal group of adolescents in recent years (Fig. 125). In 2008, this group of adolescents was centred about 65-74mm CW, and has since advanced to 89mm CW in 2010 as the leading tail of the recruitment pulse has entered legal-size. The magnitude of this group of adolescents had decreased since 2008 as crabs have grown through successive sizes. Size distributions from the fall multi-species trawl survey similarly show the presence of a group of large adolescents approaching and beginning to enter into the legal-sized group in recent years (Fig. 126).

While much of the recent recruitment pulse has now recruited to the exploitable biomass, the remaining large adolescents are expected to continue to provide strong recruitment for 2-3 years following 2011. However, several factors indicate that recruitment may have already peaked. The lack of increase in new-shelled legal-sized crabs in the CPS survey in 2010 (Fig. 121). Also, the decrease in new-shelled legal-sized crabs in the trawl survey (Fig. 122), is consistent with the reduction in the magnitude of the recruitment pulse in small-meshed traps in the CPS survey (Fig. 125) and multi-species trawl survey (Fig. 126) in showing that most of the recruitment pulse has now achieved legal size. The marginal decrease in observed catch rates of under-sized males in 2010 (Fig. 127), as well as in the percentage of the catch discarded while soft-shell prevalence has remained low (Fig. 127), further suggests that the peak level of recruitment has now occurred. Longer-term recruitment prospects are uncertain. However, the low catch rates of smallest males in the trawl survey from 2004-2008 (Fig. 126), coupled with the warm oceanographic conditions of recent years (Fig. 123), could signal reduced recruitment potential in the long-term.

Both the trap and trawl survey pre-recruit biomass indices have remained at high levels since 2007 (Table 9, Fig. 128). The increase in catch rates of pre-recruit crabs in the trawl survey during the past three years has occurred throughout the northern Grand Bank and the Div. 3N slope (Fig. 120), indicating a spatially broad-based increase.

<u>Reproduction</u>

The percentage of mature females carrying full clutches of viable eggs has exceeded 80% since 1995 with little exception (Fig. 129) and the number of mature females captured in the survey has remained consistent since 1997.

Mortality

Exploitation

Both the exploitation rate index and the pre-recruit fishing mortality rate index peaked in 2008 and have since declined (Fig. 130). The latter index was at its lowest level in 2010. The anomalously high values of both indices in 2005 and 2007 reflect the low exploitable biomass (Fig. 119) and pre-recruit biomass (Fig. 128) values from the 2004 and 2006 surveys.

Indirect fishing mortality

The percentage of the total catch discarded in the fishery (Fig. 130) increased sharply in 2008 from a low level during 2004-2007. It has since declined, implying reduced wastage of pre-recruits, primarily sub-legal sized crabs, in the fishery.

The threshold for soft-shell crab closures was changed from 20% to 15% in 2009 in Div. 3LNO (Fig. 131). The prevalence of soft-shelled crab in the catch throughout the season is typically virtually absent until early June (ie. week 12) (Fig. 131), about a month later than in Div. 3K. (Fig. 72). Soft-shell crab prevalence has been at low levels throughout the past two seasons with the exception of spikes in the last week of fishing in both years (Fig. 131). In the three previous seasons, soft-shell crab incidence generally increased after week 15. The low incidence of soft-shelled crabs throughout most of the fishery in the past two years is consistent with an increased biomass of large older-shelled crabs.

Natural Mortality (BCD)

BCD generally occurs at lower levels in Div. 3L than in Div. 3K, and has been virtually non-existent in Div. 3NO. Prevalence (in new-shelled males) from offshore Div. 3L fall multi-species trawl surveys (Fig. 132) has been variable with highest incidence during 2003-2005. Maximum prevalence was during 2004, at about 8% in 40-59 mm CW adolescents and 14% in 60-75mm CW adults. Prevalence of infection decreased considerably in 2006, and has been virtually absent in most groups of crabs since. The high prevalence levels from 2003-2005, most apparent in 40-75mm CW crabs, was likely related to high density of crabs of those sizes (Mullowney et al. 2011), consistent with recruitment pulse that has been contributing the fishery in recent years.

DIVISION 3L INSHORE

The Fishery

Landings peaked in 1996 at 7,900 t (Table 8, Fig. 133). They declined to 4,700 t in 2000, increased to 6,800 t in 2003, and decreased slightly to 6,100 t in 2005 due to changes in the TAC. They increased by 19% from 6,100 t in 2005 to 7,300 t in 2010. Meanwhile, effort decreased by 23% from 2005-2008, and has subsequently increased by 21%. CPUE has remained near the long-term average in recent years (Table 8, Fig. 134).

There has been little change in the distribution of the fishery over the past four years (Fig. 112). Most of the bays and coastal areas of Div. 3L receive considerable fishing effort each year, and there is little room for expansion within most CMAs. The temporal distribution of the 2010 fishery closely resembled the 2007-08 fisheries (Fig. 135). The fishery was delayed in starting by about 2 weeks in 2010 relative to 2009, but most of the effort had been expended by late August, as in previous years.

Biomass

CPUE increased from 2004 to the long-term average in 2007 (Table 8, Fig. 133). It has changed little during the past four years and remains near the long-term average. A high level of bias created by temporal inconsistency in the distribution of observer coverage among the various CMAs (Fig. 136) creates uncertainty in observer-based CPUE at the divisional level, and does not allow for interpretation of observer-based CPUE in some CMAs (Fig. 137). In recent years, the overall level of observer coverage has decreased, primarily due to reduced coverage in Bonavista (CMA 5A) and Trinity (CMA 6A) Bays. However, the level of coverage in other management areas such as CMA 8A has increased. The issues of interpreting observer data are further compounded by temporal inconsistencies in the coverage within each CMA, which can potentially bias CMA-specific CPUE.

There has been a general inverse relationship between the areal extent of the fishery and commercial CPUE since 1995 (Fig. 138). However, there has been limited change in the spatial extent of the fishery in recent years. The areal distribution of the fishery consists of two distinct levels, with about 30-45% of available 5’ x 5’ cells occupied each year from 1995-2001 and about 70-80% of cells occupied each year thereafter. This is attributable to localized spatial expansion of effort throughout the inshore of Div. 3L beginning in 2002, which was most pronounced in coastal regions of the Northeast Avalon and the western half of Conception Bay (Dawe et al. 2003). The sharp increase in spatial coverage of the fishery in 2002 was followed one year later by a sharp decrease in CPUE. CPUE increased from 2004-2008, and has remained at the pre-2002 level of about 10-12 kg./trap since 2007.

CPUE indices have shown a pattern of depletion throughout the season in recent years (Fig. 139). CPUE tends to be greatest at the beginning of the season each year, ranging from about 10-16 kg/trap, and declines thereafter, generally finishing at less than 8 kg/trap (Fig. 139). Most weekly CPUE values in the 2010 fishery were average relative to the five year time series. When measured against cumulative removals, the pattern of depletion becomes most pronounced during the late stages of the fishery each year (Fig. 139). In 2010, CPUE remained at about 12-14 kg/trap until 2,500 t of catch had occurred. It declined thereafter and was lower than in 2009 at total removals in excess of about 4,000 t.

The post-season trap survey index indicates the exploitable biomass has changed little over the past 7 years (Fig. 140). The catch rate of legal-sized crabs has ranged from about 20-25 crabs/trap since 2004 (Fig. 141).

Production

Recruitment

Overall, recruitment prospects have recently improved, but there is considerable spatial variability. Recruitment is expected to increase in 2011 as reflected by an increase in catch rate of legal-sized new-shelled adults in the CPS trap survey in 2010 (Fig. 141). This increase was primarily due to increased catch rates of small legal-sized crabs ranging from about 95-101mm CW (Fig. 142). The catch rate of sub-legal-sized crabs has increased in the survey during the past two years (Fig. 142), which has resulted in an increase in the pre-recruit biomass index (Fig. 143).

Mortality

Exploitation

The exploitation rate index from the post-season trap survey has varied without trend since 2005 (Fig. 140). Data are insufficient to estimate a pre-recruit fishing mortality index. Maintaining the current level of fishery removals would likely result in little change in the exploitation rate, but may increase mortality on soft-shelled immediate pre-recruits in some areas in 2011.

Indirect fishing mortality

Spatiotemporal inconsistencies in the distribution of observer coverage do not allow for a reliable index of discards at the divisional level.

Natural Mortality (BCD)

The trend in prevalence of BCD from the DFO trap survey in Conception Bay (Fig. 144) was somewhat similar to that from the multi-species trawl surveys throughout offshore Div. 3L (Fig. 132), but at higher levels of prevalence, with highest prevalence during 2004-2005. Trends in prevalence of BCD in trawl surveys in Conception Bay have been similar to those in the trap surveys (Fig. 144), but at lower levels. Prevalence generally increased to 2000 before decreasing sharply in 2001. It increased during 2002-2005 before decreasing to 2007 and remaining low in 2008-2010. Prevalence in 2008-2010 was at its lowest level since 2003 in all sizes of crabs, excepting anomalously high levels in 60-75mm CW adolescents from traps in 2008 and 2009.

Spatial variability - Trends by CMA

CMA 5A (Bonavista Bay)

Fishery CPUE has declined substantially during the past two years following the record high level of 2008, as seen in both logbook and observed catch rates (Fig. 137). Observer sampling shows that the 2010 catch was dominated by old-shelled crabs (Fig. 145). It appears that a strong recruitment pulse that became legal-sized during 2006-2007 has supported the fishery in recent years but has become depleted (Fig. 146). The CPS trap survey (Fig. 147) and the DFO trap survey (Fig. 148) are both consistent with observer data in showing a reduction in overall catch rates in recent years, primarily attributable to a reduction in new-shelled crabs. The CPS survey size frequencies show depletion across the full spectrum of legal-sized crabs following the 2009 and 2010 fisheries (Fig. 149). Recruitment prospects appear promising. Small-mesh traps (Fig. 150) and trawls (Fig. 151) in the DFO post-season surveys show an increased level of adolescent males, ranging from about 60-104mm CW, in the population during the past two years which should contribute to an increase in the exploitable biomass in the near future. Observer sampling shows a higher catch rate of undersized crabs in 2010 than in 2008 (Fig. 152), consistent with a recruitment pulse approaching legal-size. There is uncertainty regarding the level of soft-shell mortality imposed by the fishery during recent years due to inadequate observer coverage (Fig. 153). However, the scenario of a depleted biomass of legal-sized crabs coupled with an apparent increase in pre-recruits poses a risk of increased handling of soft-shelled crabs in the 2011 fishery.

CMA 6A (Trinity Bay)

Logbook and observed CPUE have gradually increased during the past two years (Fig. 137). Observer sampling indicates this is attributable to an increase in legal-sized old-shelled crabs (Fig. 154-155). However, this scenario does not fit with a normal population growth situation for snow crab, whereby an initial increase would be expected in new-shelled crabs. Therefore, there is uncertainty regarding the classification of shell conditions by observers in Trinity Bay. The CPS trap survey shows that improved catch rates in recent years are attributable primarily to an increase in legal-sized new-shelled crabs (Fig. 156), which is more consistent with an increase in the exploitable population. This increase has occurred across the entire size range of legal-sized crabs (Fig. 157). The recent increase in CPUE and the exploitable biomass is likely the result of a group of adolescents approaching legal-size, first evident in small-mesh traps in the CPS survey at about 35-50mm CW in 2005 (Fig. 158). Recruitment should increase further over the next few years as the remainder of this recruitment pulse enters into the legal-size range. The increase in undersized crabs in the catch in 2010 (Fig. 159) is consistent with the increasing recruitment into the exploitable biomass, as is the relatively high levels of soft-shell crab observed in the catch in June and July in 2010 (Fig. 160). The level of fishery-induced mortality imposed by catching and releasing soft-shelled crabs in recent years is unknown due to insufficient observer coverage.

CMA 6B (Conception Bay)

Commercial CPUE increased from 2006-2008 and has since remained high, based on both logbook and observer indices (Fig. 137). Observer sampling shows an increase in new-shelled legal-sized crabs in 2007-2008, which has subsequently been followed by an increase in old-shelled legal-sized crabs (Fig. 161). The increase was initially greatest in small legal-sized males of about 95-101mm CW in 2007-08, but has since expanded to include larger males (Fig. 162). Large-mesh traps in both the CPS (Fig. 163) and DFO (Fig. 164) trap surveys show that catch rates of legal-sized crabs were at all-time highs in 2009, but decreased during 2010 due to reductions in the catch rates of new-shelled crabs. However, both indices remain high. There is conflicting information on recruitment potential. Trap surveys show that the population of crabs in Conception Bay is characterized by a high abundance of sub-legal-sized adults (Fig. 165-167). Small-mesh traps in both the CPS (Fig. 166) and DFO (Fig. 167) trap surveys indicate that virtually all pre-recruit-sized crabs captured in the past three years are terminally molted adults that will never contribute to the fishery, thus a decrease in fishery recruitment over the next few years is inferred. However, trawl sets in the DFO surveys (Fig. 168) show that there has been a large increase in the catch rates of pre-recruit-sized adolescents in the past two years, which would imply increased recruitment potential in the short-term. However these increases occurred across the full size range of undersized crabs, implying changes in trawl efficiency (year effects). A better understanding of the catchability of different groups of crabs by different survey gears is necessary in order to evaluate recruitment potential in this area. There has been no change in discard rates of under-sized or soft-shelled crabs since 2002. The fishery has apparently imposed little mortality to soft-shelled crabs during the past three years (Fig. 170), and the percentage of the catch discarded has been decreasing (Fig. 169). This implies little wastage by the fishery in this bay in recent years.

CMA 6C (Northeast Avalon)

With the exception of a small increase in 2008, fishery CPUE has changed little over the past eight years (Fig. 137), remaining at about 8 kg/trap. This relative consistency in CPUE is reflected by relative consistency in catch rates of legal-sized crabs in the CPS survey, which, with the exception of a spike in 2006, has remained at about 14 crabs/trap since 2004 (Fig. 171). Fishery recruitment is expected to change little in 2011, with no change in the catch rates of legal-sized new-shelled males in the CPS survey in 2010 (Fig. 171). There has been little change in the abundance of all sizes of legal-sized crabs in the past five years, although the abundance of sub-legal-sized crabs has increased (Fig. 172). A high proportion of the pre-recruit-sized crabs in the CPS survey small-meshed trap catches were terminally molted adults (Fig. 173), likely reflecting their greater catchability than adolescents. However, the catch rate pre-recruits (76-94 mm CW adolescents) in 2010 was higher than it had been in the previous five years (Fig. 173), implying relatively strong recruitment in the short-term. Observer data are insufficient to estimate the incidence of soft-shelled crabs throughout the season.

CMA 8A (Southern Avalon)

Fishery CPUE increased from 2005-2008 and has since declined (Fig. 137). This decline is reflected in a decline in catch rate of old-shelled crabs in the post-season CPS trap survey (Fig. 174). In 2010, the survey catch rate of legal-sized crabs was at its highest level, primarily due to a sharp increase in the catch rate of new-shelled crabs (Fig. 174), implying increased recruitment for the 2011 fishery. There is strong internal consistency in the data during the limited time series for which the CPS survey has occurred, with a peak in new-shelled crab abundance in 2007 followed by a peak in old-shelled crabs in 2008. If the consistency in the data series holds, the high level of legal-sized new-shelled crabs in 2010 would be expected to contribute to an increased old-shelled biomass in 2011. The increased catch rates of legal-sized crabs in 2010 occurred primarily in small legal-sized crabs, ranging from about 95-113mm CW (Fig. 175), indicating the entry of a recruitment pulse into legal-size. The increased catch rates of sub-legal-sized crabs in the 2010 survey (Fig. 175) could reflect improved recruitment prospects for the short-term beyond 2011. Longer-term recruitment prospects are unknown, and observer data are insufficient to estimate seasonal trends in incidence of soft-shelled crabs.

CMA 9A (St. Mary's Bay)

Commercial CPUE has varied between about 15-23 kg./trap since 1999 (Fig. 137), with little change from 2009 to 2010. The CPS trap survey catch rate of legal-sized crabs nearly doubled in 2010, to a very high level of about 60 crabs/trap (Fig. 176). This sharp increase was primarily attributable to an increase in new-shelled crabs (Fig. 176), ranging in size from 98-107mm CW (Fig. 177). Recruitment potential appears very positive, with a dramatic increase in the abundance of sub-legal-sized crabs in the survey in the past two years (Fig. 177-178). Small-mesh trap samples reveal that this group of crabs approaching legal-size is predominately comprised of adolescent crabs (Fig. 178), with few terminally molted adults in the trap samples. Therefore, fishery recruitment levels should increase over the next few years. Longer-term recruitment prospects are unknown and observer data are insufficient to describe seasonal trends in incidence of soft-shelled crabs. However, there is potential for a high incidence of soft-shell crab in the fishery in 2011 if the level of exploitation on the exploitable biomass is too high.

SUBDIVISION 3Ps OFFSHORE

The Fishery

Landings (Table 10, Fig. 179) varied little, at 4,300-4,400 t during 1999-2002, before declining by about half to 2006. They increased by 70% from 2,300 t in 2006 to 3,900 t in 2010. Meanwhile, effort decreased from 2006 to 2008 and increased slightly to 2010. CPUE declined substantially from 1999-2005 before increasing to 2009 and changed little in 2010 (Table 10, Fig. 180).

The spatial distribution of the fishery has remained similar over the past four years (Fig. 181) but there have been some subtle changes. In most years, the bulk of offshore fishing effort is expended between the St. Pierre and Green Banks in CMA 10BCD (Fig. 1), in an area known as Halibut Channel. In 2010, the effort was more concentrated in the northern portion of Halibut Channel than in previous years (Fig. 181). The effort on the slope along the northwest portion of the St. Pierre Bank has also increased during the past three years. The temporal distribution of the 2010 fishery was also delayed relative to the previous four years, with a minimal amount of effort expended before May and the fishery extending into late July (Fig. 182). The management shift toward a spring fishery has been more successful in Subdiv. 3Ps than in any other division. This is likely due in large part to a lack of spring ice cover along the south coast. The delay in the 2010 fishery was likely attributable to the price dispute early in the season.

Biomass

The three CPUE indices are consistent in showing an increasing trend in catch rates from 2005-09 (Fig. 180). In 2010, the observer index increased slightly while the logbook and VMS indices decreased slightly. The largest increases in CPUE during the 2005-09 period occurred in the northern portion of Halibut Channel (Fig. 183), and the 2010 spatial distribution of CPUE was very similar to that during the 2009 fishery.

The spatial coverage of the fishery has generally been inversely related to commercial CPUE since 1999 (Fig. 184). The percentage of available 5' x 5' cells occupied by the fishery increased steadily from 1995 to an initial peak in 2002. It then declined gradually in 2003 and 2004 before increasing sharply to its highest level of 75% in 2005. This is likely attributable to a high incidence of soft-shelled crab in the fishery in 2005 (Dawe et al. 2006). The spatial index declined sharply in 2006 and has since changed little, with about 50% of the available cells occupied by the fishery in 2006-10.

Catch rates have shown high levels of weekly variability, but show that the fishery has performed better throughout the season during each of the past three years than it did in 2006-07 (Fig. 185). In 2010, there was little change in weekly CPUE after an initial decrease that occurred after two weeks of fishing. There was little catch removed during these initial two weeks, and by the time the fishery had removed about 500 t the CPUE had decreased to 300 kg/hour and remained at that level throughout the remainder of the season (Fig. 185).

Size distributions from at-sea sampling by observers (Fig. 186) showed a sharp ('knife-edge') decrease in catch rate at 95mm CW from 2005-2007, suggesting high fishery-induced mortality on legal-sized crabs, including new-shelled immediate pre-recruits, in those years. However, this sharp knife-edge effect was not present in 2008-10, due to a decrease in catch rate of sub-legal sized crabs and an increase in catch rate of legal-sized crabs. This could be due to increased recruitment and/or decreased exploitation rate. The high catch rates of undersized (<95 mm CW) crabs in most years, and the high proportion of those that were old-shelled, suggests that crabs terminally molt to adulthood at small sizes in Subdiv. 3Ps relative to most other areas.

The observed catch rate of legal-sized new-shelled crabs decreased sharply in 2001, followed by a sharp decrease in catch rate of legal-sized old-shelled crabs in 2003 (Fig. 187). Catch rates of old-shelled crabs have consistently been higher than those of new-hard-shelled crabs, and catch rates of soft-shelled crabs have been virtually nil each year after 1999, with the exception of 2005. Both the new and old-shelled components gradually increased from 2007-09, with a decrease in the catch rate of old-shelled crabs in 2010. Trends in the catch rates of new-shelled and old-shelled legal-sized crab, when combined (exploitable crabs), have reflected the catch rate of all crabs retained since 2000.

The exploitable biomass, as indicated by both the spring trawl survey and the post-season trap survey indices, increased steadily from 2006-2009 and then decreased slightly in 2010 (Table 11, Fig. 188). The trawl survey index remains below the pre-2000 level. The greatest increase in catch rates of exploitable crabs in the trawl survey occurred in 2009 in the northern portion of Halibut Channel (Fig. 189). This is also the area with the greatest decreases in catch rates in 2010. The CPS trap survey catch rates of legal-sized crabs showed that old-shelled crabs have increased each year since 2007 (Fig. 190), consistent with the trawl survey which has shown a similar increase in intermediate-shelled crabs during that time (Fig. 191).

Effect of ocean climate variability

The exploitable biomass index is inversely related to a lagged (seven year) index of bottom temperature at shallow depths in offshore Subdiv. 3Ps (Fig. 192). The exploitable biomass index is also directly related to the spatial extent of <0°C water (Fig. 192). These relationships are consistent with those found in other areas and suggest that a cold ocean climate regime during early life history promotes early survival and subsequent recruitment to the fishery. The warming bottom temperatures and small spatial coverage of <0°C water in recent years implies reduced recruitment potential going forward.

Production

Recruitment

Recruitment has recently increased as reflected by an increase in biomass while landings increased. This is also reflected in the increase in legal-sized old-shelled crabs, both in the CPS trap and spring trawl surveys (Fig. 190-191). Recruitment appears promising for 2011 as reflected by catch rates of new-shelled legal-sized crabs in the trap survey (Fig. 190), which has varied without trend since 2005, and the trawl survey, which remained at a relatively high level in 2010 (Fig. 191).

Size distributions from the post-season trap survey large-meshed traps showed a substantial increase in catch rates of sub-legal-sized soft-shelled crabs in 2005 (Fig. 193). Since then, the catch rate of most sizes of legal-sized crabs has increased, especially in

2009. The proportion of old-shelled crabs in the survey catch increased in 2010, due to a decrease in the catch rate of new hard-shelled crabs. The high catch rates of undersized (<95 mm CW) crabs in most years, and the high proportion of those that were old-shelled, supports our earlier suggestion that crabs terminally molt to adulthood at smaller sizes in Subdiv. 3Ps relative to other areas. This can be seen in size distributions from small-mesh traps in the CPS survey which show that almost all males greater than 53 mm CW in the past two years were terminally molted adults (Fig. 194).

Size distributions from the spring trawl survey reflect the presence of a modal group of adolescents first observed in 2005 at a modal size of about 66 mm CW (Fig. 195). These adolescents achieved a modal size of about 87 mm CW in 2008, and began to achieve legal size in 2008 and 2009, evident by increased abundance of adolescent and adult crabs ranging from 96-108 mm CW. There was a large reduction in catch rate of pre-recruits (76-94mm CW adolescents) in 2010, indicating that most of this recruitment pulse has now progressed to legal size.

At-sea observer sampling showed a decrease in catch rate of under-sized crabs in 2010 (Fig. 196), but the decrease did not extend back to 2008, as was evident in the trawl survey size frequencies (Fig. 195). The observer data show that virtually all discards in the fishery have been under-sized crabs since 2005, with no indication of soft-shelled crabs in the catch in recent years (Fig. 196).

The post-season trap survey pre-recruit index has varied without trend since 2005 (Fig. 197). Meanwhile, the pre-season trawl survey pre-recruit index increased greatly from 2005-2009 but decreased sharply in 2010 (Table 11, Fig. 197). Therefore, recruitment is expected to decline following 2011. The decline in catch rate of pre-recruit crabs by the survey trawl occurred throughout the offshore in 2010 (Fig. 198), but was most severe in the furthest offshore regions.

Reproduction

The number of females captured increased sharply from 2001-2002, and has since declined to a low level during 2007-10 (Fig. 199). There is high annual variability in the percentage of females carrying full clutches of viable eggs (Fig. 199), but greater than 90% of females carried full clutches of eggs in each of the past three years.

Mortality

Exploitation

Exploitation and pre-recruit fishing mortality rates, as indicated by spring trawl survey indices, decreased from 2007-2009 but increased in 2010 (Table 11, Fig. 200). The indices remain well below the peaks in 2003 and 2004. Maintaining the current level of fishery removals would likely have little effect on the exploitation rate in 2011.

Indirect fishing mortality

The percentage of the total catch discarded in the fishery (Fig. 200) peaked at about 45% in 2005, declined by half to 2008 and has since changed little, implying a reduction in wastage of pre-recruits in recent years. The percent discarded in Subdiv. 3Ps is generally higher than in other areas as it includes a larger component of under-sized crabs, an unknown but high portion of which is comprised of small adults that will never recruit to the fishery. Soft-shelled crab has been virtually absent in the observed catch since 2006 (Fig. 201). Therefore, mortality resulting from catching and handling soft-shelled crab is assumed to me minimal in recent years.

Natural Mortality (BCD)

Small-meshed trap data from the CPS trap survey indicates that BCD has been detected, at low prevalence levels in offshore Subdiv. 3Ps in 2005-2006, but not in 2007-10 (unpublished data).

SUBDIVISION 3Ps INSHORE

The Fishery

Landings (Table 10, Fig. 202) varied little, at 3,300-3,600 t during 1998-2002, before declining by a factor of 5 to 2005. They then increased from 700 t in 2005 to 2,200 t in 2010 as effort declined slightly. CPUE declined from 2001-2005 and has since increased steadily to its highest level since 1996 (Table 10, Fig. 203).

The spatial distribution of the fishery has changed little over the past four years (Fig. 181), with most effort expended in Placentia Bay in CMA 10A (Fig. 1). The commercial fishery in Fortune Bay (CMA 11E, Fig. 1) has been closed since 2005, with a small-scale monitoring fishery occurring each year since the closure. The pattern of fishing in Fortune Bay has been variable among years, with the level of effort expended in the inner versus outer portions of the bay changing each year. Temporally, similar to the offshore, the 2010 fishery was delayed relative to the previous four years, with a minimal amount of effort expended before May (Fig. 204). The delay did not result in a late end to the season however, with most effort expended by week 10, as in previous years. As in the offshore, the management shift toward a spring fishery has been more successful in Subdiv. 3Ps inshore than in other divisions, likely attributable to the lack of spring ice cover.

Biomass

Logbook CPUE increased rapidly since 2006 and was at a high level in 2010 (Fig. 203). A high level of bias created by spatial and temporal inconsistency in the distribution of observer coverage among the various CMAs (Fig. 205) creates uncertainty in observer-based CPUE at the sub-divisional level, and especially compromises interpretation of CPUE at the CMA level (Fig. 206). In recent years, the distribution of observer coverage between Placentia (CMA 10A) and Fortune (CMA 11E) Bays has been highly inconsistent. For example, virtually all observer coverage occurred in Placentia Bay from 2006-08 but Fortune Bay received the bulk of coverage in 2009 (Fig. 205). There was a relatively even distribution between the two areas in 2010. This spatial bias is further compounded by temporal inconsistencies in the coverage within each CMA from year to year.

The spatial coverage of the fishery has been inversely related to commercial CPUE since 1995 (Fig. 207). The percentage of available 5’ x 5’ cells occupied by the fishery has been decreasing in recent years while CPUE has been increasing. About 15-20% of the available fishing grounds have been targeted each year since 2003.

Trends in commercial CPUE throughout the season (Fig. 208) indicate that CPUE was higher throughout most of the season in 2010 than in any of the previous 4 years. There was little suggestion of a depletion effect with time or level of removals in 2008 or 2009, but catch rates did decline after about 900 t of removals in 2010 (Fig. 208).

The exploitable biomass, as indicated by the post-season trap survey index, increased substantially between 2006 and 2008 and has since changed little (Fig. 209).

Production

Recruitment

Recruitment has recently increased, as reflected by an increase in the post-season trap survey catch rate of new-shelled legal-sized adults (Fig. 210-211), and prospects for 2011 and 2012 are promising. The trap survey pre-recruit biomass index increased in 2007 and has since remained above the 2004-2006 level. The pre-recruit biomass index for this subdivision includes a high proportion of small adults (Fig. 211) that will never recruit to the fishery.

Mortality

Exploitation

The post-season trap survey-based exploitation rate index changed little during 2008-2010 (Fig. 209). Data are insufficient to estimate a pre-recruit fishing mortality rate index. Maintaining the current level of fishery removals would likely have little effect on the exploitation rate in 2011.

Indirect fishing mortality

Spatiotemporal inconsistencies in the distribution of observer coverage do not allow for a reliable index of discards at the sub-divisional level.

Natural Mortality (BCD)

Small-meshed trap data from the collaborative post-season trap survey indicates that BCD was occasionally detected, at low levels prior to 2004 in inshore Subdiv. 3Ps, but absent since (unpublished data).

Spatial variability: Trends by CMA

CMA 10A (Placentia Bay)

Fishery performance has improved substantially since 2006, as indicated by both logbook and observer CPUE indices (Fig. 206). Observer sampling indicates that the abundance of exploitable crabs has increased in recent years and the catch has been comprised of a roughly even mix of old- and new-shelled crabs in most years since 2005 (Fig. 213). The increased catch rates have predominately occurred in small legal-sized adults, ranging from about 95-110mm CW (Fig. 214). Recruitment for 2011 appears positive, with the new-shelled legal-sized component of the CPS trap survey reaching a seven-year high in 2010 (Fig. 215). Consistent with observer sampling, the CPS catch rates of legal-sized crabs have been highest for small exploitable males, ranging from about 95-110mm CW (Fig. 216). Long-term recruitment prospects are uncertain, but small-mesh traps from the CPS survey indicate the majority of sub-legal-sized crabs captured in the past few years have been terminally molted adults (Fig. 217). However, these traps are spatially limited, generally set in shallow water, thus there is uncertainty in their ability to project recruitment prospects for the area as a whole. The percentage of the catch discarded has dropped by half since 2006 (Fig. 218), and there has been very little incidence of soft-shelled crabs in the fishery in recent years (Fig. 218-219), indicating little wastage of the resource.

CMA 11E (Fortune Bay)

CPUE has varied without trend since 2003 (Fig. 206). There was a small increase in 2010, consistent by both logbook and observer catch rate indices. The marginal increase in 2010 occurred in both new-shelled and old-shelled crabs (Fig. 220), and across most sizes of males in the legal-size range (Fig. 221). The 2010 CPS survey indicates that the exploitable biomass has recently increased, primarily attributable to an increase in new-shelled legal-sized crabs (Fig. 222). The DFO trap survey shows that the increases in biomass have occurred in the shallow and intermediate depths of the Bay (strata 294-295), with decreased catch rates in legal-sized crabs in the deepest portions of the bay (stratum 296) since 2007 (Fig. 223). The high catch rate of new-shelled legal-sized crabs in the CPS survey indicates that recruitment should be relatively strong in 2011, but small-mesh traps in both the CPS and DFO surveys show that the majority of sub-legal-sized crabs captured in the past two years are terminally molted adults (Fig. 225-226), which could signify reduced levels of recruitment thereafter. However, as in other areas, a greater understanding of trap selectivity is necessary to definitively interpret recruitment potential from these small-mesh traps. Soft-shelled crabs have been virtually absent in the fishery during the past two years (Fig. 227-228), and the percentage of the catch discarded has been lower than it was from 1999-2003. This implies that wastage levels by the fishery have been reduced in recent years.

CMA 11W (Pass Islands)

Commercial CPUE initially peaked at 8kg./trap in 1998, and declined to a low of 2kg./trap in 2003 (Fig. 207). It has since increased steadily, to a high of 11kg./trap in 2009-10. There is no available information from which to infer recruitment prospects.

DIVISION 4R3Pn OFFSHORE

The Fishery

Landings declined substantially from 580 t in 2004 to 80 t in 2006 before more than doubling in 2007 (Table 12, Fig. 229). They declined by 83% from 190 t in 2007 to a historical low of 30 t in 2010, while effort declined by 91%. The TAC has not been taken since 2002. CPUE declined slightly from 2006-2009 but increased sharply in 2010 (Table 12, Fig. 230). However, the 2010 increase was associated with a record low level of both landings and effort. CPUE has consistently been low relative to other divisions.

The fishing pattern has remained similar in recent years, despite the declining levels of effort each year (Fig. 231). The main concentrations of effort have been in the northwest portion of the Division and outside of the Bay of Islands along the CMA 12E (Fig. 1) line. The levels of effort in these areas have dissipated greatly since 2007, and the fishery was virtually abandoned in 2010. The length of time required for most of the effort to be expended has become progressively shorter in recent years (Fig. 231). In 2010, nearly all effort was expended by week 7 (late May), about a month and a half earlier than in 2006.

Biomass

Fishery catch rates have been poor throughout the offshore since 2005 (Fig. 232), rarely exceeding 5 kg/trap. In contrast to other areas, CPUE and the spatial extent of the fishery have not shown a tendency to be negatively related over most of the time series (Fig. 233). The spatial extent of the fishery has been in decline since 2000, with only 5% of the grounds covered in 2010. In other areas, this is normally opposed by an increase in fishery performance, however in this case the continued poor fishery performance coupled with the spatial contraction of effort likely reflects low exploitable biomass. The high 2010 CPUE is due to minimal effort and landings.

Commercial CPUE throughout the season was initially high in 2010 (Fig. 234), peaking after two weeks of fishing (week 3). CPUE fell off quickly thereafter, and by week 6 was at a low level as in the previous four years. The abrupt decline in catch rates in 2010 occurred with only about 10-20 t of catch removed.

The exploitable biomass is low as reflected by virtual abandonment of the fishery in recent years. The post-season trap survey index decreased in 2009 and was unchanged in 2010 (Fig. 235). The post-season trawl survey index has fluctuated without trend throughout the time series (Table 13, Fig. 235), due to sporadic survey catches each year.

The 2010 trawl survey was incomplete in southern areas with no sets south of the Port aux Port Peninsula (Fig. 236). However, as this is not an area where crabs have been captured in recent years, the effect on the biomass index is thought to be negligible. There were only two tows that captured legal-sized crabs in the offshore area in 2010 (Fig. 236). The CPS trap survey indicates that the few legal-sized crabs captured in 2010 were exclusively old-shelled.

Production

Recruitment

Recruitment has been low in recent years, resulting in a low exploitable biomass despite declining landings. The catch rate of legal-sized new-shelled crabs in the CPS trap survey has not exceeded 1 kg./trap during each of the past three years and was zero in 2010 (Fig. 237).

Size frequencies from large-meshed traps in the CPS survey (Fig. 238) show no clear trend in crabs of any size, with few crabs captured during each of the past four years. Small-mesh traps from the CPS survey (Fig. 239) showed a small group of adolescents at about 50-56mm CW in 2008-09, but captured virtually no crabs in 2010. Size frequency distributions for the trawl survey are consistent is showing few male crabs greater than 30 mm CW captured in 2010.

Recruitment prospects for the short-term are poor. The post-season trap survey pre-recruit index was unchanged during 2007-2009 but decreased in 2010 (Fig. 239). There were only two catches of pre-recruit-sized crabs by the survey trawl in 2010 (Fig. 240).

Longer-term recruitment prospects are unknown.

Mortality

Exploitation

The time series of information from the post-season trap survey is insufficient to interpret any trend in the exploitation rate index. Data are insufficient to calculate a pre-recruit fishing mortality index. Maintaining the current level of fishery removals would likely result in little change to the exploitation rate in 2011.

Indirect fishing mortality

The observer data are insufficient to estimate the percentage of the catch discarded in the fishery or to infer wastage of pre-recruits.

DIVISION 4R INSHORE

The Fishery

Landings (Table 12, Fig. 241) declined by 90% from 950 t in 2003 to 190 t in 2010 (Fig. 46), while effort declined by 60%. Landings and effort were at historical lows in 2010 and the TAC has not been taken since 2002. CPUE declined steadily from 2002 to its lowest level in 2008 and has since changed little (Table 12, Fig. 242).

The spatial distribution of the fishery has changed in recent years (Fig. 231). Fishing effort in Bay St. George (CMA 12C, Fig. 1) has increased and become more widespread, particularly in the outer portions of the Bay, in recent years. Effort has all but disappeared in CMA 12D (Fig. 1) off the Port aux Port Peninsula since 2007 (Fig. 231), while effort on the inner portions of the Bay of Islands in CMA 12F (Fig. 1) and CMA 12H (Fig. 1) has increased since 2007 (Fig. 231). CMA 12G (Fig. 1) has been un-fished since a voluntary moratorium was imposed in 2009. Temporally, the 2010 fishery was delayed in starting, by three weeks relative to 2009, and finished about 2-3 weeks earlier than the fisheries of the preceding three years. The 2010 fishery ran from early May to mid June.

Biomass

Annual trends in CPUE (Fig. 242) are influenced by spatial variation in fishery performance among management areas (Fig. 244). Both CPUE and the spatial extent of the fishery increased sharply in 2002 before steadily declining to 2008 and 2007 respectively (Fig. 245). The spatial extent of the fishery has remained low in recent years, with 6 to 10% of the grounds covered each year since 2006, while CPUE has remained near its lowest level, at less than 5 kg/trap during that time.

Commercial logbook CPUE throughout the season and in relation to cumulative catch (Fig. 246) showed an earlier and more abrupt pattern of seasonal depletion in 2010 than in the fisheries of the previous four years. Catch rates were highest in the earliest portion of the season and fell off quickly thereafter.

The post-season trap survey exploitable biomass index changed little between 2005 and 2009 but increased in some management areas in 2010 (Fig. 247).

Production

Recruitment

Recruitment has recently increased, as reflected by an increase in the post-season trap survey catch rate of new-shelled legal-sized crabs in 2010 (Fig. 248). This increase occurred across the entire size-range of crabs greater than 95mm CW. Prospects remain promising for the next two to three years, but there is considerable variability among management areas. The CPS trap survey shows an increase in new-shelled crabs ranging from about 80-92mm CW in 2010 (Fig. 249). The post-season trap survey pre-recruit biomass index increased in 2009 and decreased slightly in 2010 but remained above the pre-2009 level (Fig. 250).

Mortality

Exploitation

The post-season trap survey exploitation rate index has changed little since 2005 (Fig. 48). Increased fishery removals would not likely increase the exploitation rate in 2011, but may increase mortality on soft-shelled immediate pre-recruits in some management areas.

Indirect fishing mortality

The observer data are insufficient to estimate the percentage of the catch discarded in the fishery or to infer wastage of pre-recruits.

Spatial variability: Trends by CMA

CMA 12C + BSG (Bay St. George)

Fishery CPUE has been gradually increasing each year since a rapid decease from 2002-05 (Fig. 244), but still remains low relative to historic levels. The post season trap survey catch rates of legal-sized crabs have been higher in the past three years than they were from 2004-07 (Fig. 251), but the exploitable biomass is still low relative to most areas. An initial increase in catch rate of new-shelled crabs in 2008 was followed by an increase in old-shelled crabs in 2009. This has subsequently been followed by a second increase in new-shelled catch rates in 2010, which implies positive recruitment prospects for 2011. It appears that a recruitment pulse has begun to enter into the exploitable biomass. However, the catch rates of under-sized crabs in both large-meshed (Fig. 252) and small-meshed (Fig. 253) traps in the CPS survey were higher than those of legal-sized crabs, which implies further recruitment in the forthcoming years. There is potential for a high incidence of soft-shelled crab in the 2011 fishery under the scenario of a low exploitable biomass and high level of incoming recruitment.

CMA 12E (Outer Bay of Islands)

Commercial CPUE peaked at 11 kg./trap in 2002 and has declined since, with a low of 3 kg./trap in 2009 (Fig. 244). The CPS survey catch rate of legal-sized crabs has declined since 2005, to a low in 2008-2010 (Fig. 254). This reflects decreased catch rates of both new-shelled and old-shelled legal-size crabs of all sizes in recent years (Fig. 255). Short-term recruitment prospects do not appear favourable and long-term prospects are unknown.

CMA 12F + BOI (Bay of Islands)

Commercial CPUE peaked at 12 kg./trap in 2004 and has since declined, to about 4 kg./trap from 2008-10 (Fig. 244). The catch rate of new-shelled legal-sized crabs in the CPS survey has varied without trend since 2004, while the catch rate of old-shelled legal-sized crabs has decreased since 2005 (Fig. 256). Total catch rate of legal-sized crabs in the CPS survey was at its lowest in 2009, but increased in 2010. The increase was attributable to increased catch rates of all sizes of legal-size crabs in 2010 (Fig. 257), which implies increased recruitment for 2011. Recruitment prospects in the short-term following 2011 appear favourable, with a pulse of adolescent crabs ranging from about 68-92mm CW approaching legal-size (Fig. 258). There is potential for a high incidence of soft-shelled crab in the 2011 fishery under the scenario of a low exploitable biomass and an increasing level of recruitment.

CMA 12G (Bonne Bay)

Fishery CPUE plummeted from 2003-08 (Fig. 244), prompting a voluntary fishing moratorium in 2009. The fishery is scheduled to re-open in 2011. The CPS trap survey indicates that catch rates of legal-sized new-shelled crabs have been increasing since 2007, with an especially large increase in 2010. This should result in an increased exploitable biomass available to the fishery relative to that prior to the closure. Short-term recruitment prospects beyond 2011 are uncertain. The high catch rates of sub-legal-sized crabs in large-mesh traps in the CPS trap survey in 2010 (Fig. 260) imply positive prospects, but small-mesh traps from that survey indicate that most of a recruitment pulse present at a mode of about 71mm CW in 2008 have now progressed into legal-size.

CMA 12D, CMA 12H

There are inadequate data to assess resource status.

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Table 1: Annual Overall (Divisions 2HJ3KLNOP4R) Total Allowable Catch (TAC) and Landings, by year.

YEAR	TAC (t)	LANDINGS (t)
1995	27,875	32,334
1996	34,864	37,967
1997	42,015	45,726
1998	49,225	52,677
1999	61,806	69,131
2000	51,169	55,434
2001	52,267	56,727
2002	56,981	59,418
2003	56,250	58,362
2004	53,590	55,675
2005	49,978	43,958
2006	46,233	47,238
2007	47,663	50,207
2008	54,338	52,775
2009	54,110	53,451
2010	56,087	52,215

Table 2: Annual Total Allowable Catch, Landings, Effort and Catch Per Unit Effort (CPUE) for Division 2H.

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
2004		10	2326	267.3
2005		67	10635	305.8
2006		152	12258	891.0
2007		193	16083	520.5
2008	100	141	14242	405.8
2009	100	86	10750	359.0
2010	100	70	11864	361.5

Table 3: Fall multi - species survey exploitable and pre - recruit biomass indices with confidence intervals and mean catch, by year, for Division 2H.

YEAR	EXPLOITABLE CRAB IN 2H				PRE - RECRUIT CRAB IN 2H			
	BIOMASS (t)			MEAN (kg/set)	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower		ESTIMATE	Upper	Lower	
1998	23	231	-184	0.02	12	162	-138	0.01
1999	12	159	-136	0.01	0	0	0	0.00
2004	132	307	-43	0.10	404	943	-135	0.29
2006	303	996	-390	0.22	138	276	0	0.10
2008	97	443	-249	0.08	63	300	-175	0.05
2010	87	906	-733	0.07	0	0	0	0.00

Table 4: Annual Total Allowable Catch, Landings, Effort and Catch Per Unit Effort for Division 2J (Offshore only).

YEAR	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1995	3050	3189	393704	
1996	2800	3102	326526	
1997	2800	3183	286757	
1998	3500	4098	284583	
1999	4655	5416	401185	
2000	3411	3682	304298	
2001	3340	3754	426591	
2002	3381	3520	577049	
2003	2265	2510	583721	
2004	1780	1915	531944	143.6
2005	1425	1509	284717	197.1
2006	1425	1987	242317	285.5
2007	1570	2330	256044	410.2
2008	2366	2408	225047	391.2
2009	2366	2301	284074	385.1
2010	2127	2061	278514	250.1

Table 5: Fall multi - species survey exploitable and pre - recruit biomass indices with confidence intervals and mean catch, by year, for Division 2J.

YEAR	EXPLOITABLE CRAB IN 2J				PRE - RECRUIT CRAB IN 2J			
	BIOMASS (t)			MEAN (kg/set)	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower		ESTIMATE	Upper	Lower	
1995	3472	4806	2138	1.29	2031	2943	1119	0.75
1996	6120	8262	3977	1.92	2965	4321	1608	0.93
1997	10675	16366	4983	3.36	2992	4227	1758	0.94
1998	12667	18226	7109	3.98	3380	4532	2227	1.06
1999	6292	8384	4201	1.98	1156	1977	335	0.36
2000	3555	4525	2584	1.13	1269	1857	681	0.40
2001	3249	4078	2421	1.02	1313	3207	-581	0.41
2002	852	1312	392	0.27	589	2883	-1705	0.19
2003	1015	1686	343	0.32	917	1311	523	0.29
2004	1334	1953	716	0.42	4399	33047	-24248	1.38
2005	2009	10750	-6733	0.63	1657	3655	-341	0.52
2006	3067	10931	-4797	0.96	2158	4797	-480	0.68
2007	2787	4402	1172	0.88	1306	3042	-429	0.41
2008	1976	2922	1029	0.62	1174	4580	-2231	0.37
2009	1464	2566	361	0.46	1675	11754	-8405	0.53
2010	1513	2450	577	0.48	1007	4916	-2901	0.32

Table 6: Annual Total Allowable Catch, Landings, Effort and Catch Per Unit Effort for Inshore and Offshore Division 3K.

YEAR	INSHORE 3K				OFFSHORE 3K			
	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	LOGBOOK CPUE (kg/trap)	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1995	1950	1950	237805	8.2	9500	10376	741143	
1996	3450	3267	510469	6.4	9500	10943	835344	
1997	3450	3122	538276	5.8	10850	11674	871194	
1998	3040	2781	487895	5.7	12700	14103	946510	
1999	3242	3460	865000	4.0	14950	17898	1345714	
2000	2275	2328	485000	4.8	11218	13056	1186909	
2001	2475	2757	306333	9.0	11218	12519	1251900	
2002	3195	3481	429753	8.1	12183	12870	1191667	
2003	3425	3585	535075	6.7	12183	12922	1242500	
2004	3410	3527	665472	5.3	12183	12943	1703026	239.4
2005	3115	2707	575957	4.7	9745	5972	853143	213.2
2006	2635	2728	426250	6.4	7795	7984	694261	344.1
2007	2820	3056	315052	9.7	8930	9215	626871	490.7
2008	3455	3456	300522	11.5	11620	11612	699518	459.9
2009	3695	3585	426786	8.4	12780	12599	1211442	306.9
2010	3395	2807	501250	5.6	11045	9613	1033656	259.5

Table 7: Fall multi - species survey exploitable and pre - recruit biomass indices with confidence intervals and mean catch, by year, for Division 3K.

YEAR	EXPLOITABLE CRAB IN 3K				PRE - RECRUIT CRAB IN 3K			
	BIOMASS (t)			MEAN (kg/set)	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower		ESTIMATE	Upper	Lower	
1995	11676	14534	8817	2.84	7424	9924	4925	1.81
1996	20234	24352	16116	4.92	10632	14312	6952	2.59
1997	18712	22724	14700	4.55	13405	17865	8945	3.26
1998	18918	23156	14679	4.60	9992	13912	6071	2.43
1999	8674	11366	5982	2.11	3487	4871	2104	0.85
2000	9976	12668	7283	2.59	9608	13251	5965	2.49
2001	11886	16482	7289	2.89	6681	8933	4429	1.62
2002	9042	11742	6342	2.20	5178	7343	3012	1.26
2003	3644	4603	2685	0.89	2461	4047	875	0.60
2004	5550	7061	4039	1.35	5378	8989	1767	1.31
2005	6969	8897	5041	1.69	5765	7867	3664	1.40
2006	10939	13469	8409	2.78	9971	15093	4848	2.53
2007	16887	22236	11538	4.11	5256	7199	3313	1.28
2008	16157	21399	10914	3.93	8220	12306	4134	2.00
2009	7928	10301	5554	1.93	5684	7796	3573	1.38
2010	6792	8668	4916	1.65	4044	5854	2233	0.98

Table 8: Annual Total Allowable Catch, Landings, Effort and Catch Per Unit Effort for Inshore and Offshore Divisions 3LNO.

YEAR	INSHORE 3L				OFFSHORE 3LNO			
	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	LOGBOOK CPUE (kg/trap)	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1995	6475	6795	471875	14.4	5175	7212	389838	
1996	7675	7922	665714	11.9	7100	8494	534214	
1997	5850	6398	627255	10.2	13075	14293	898931	
1998	7225	6882	583220	11.8	13250	15111	873468	
1999	5350	5453	482566	11.3	24275	27329	1518278	
2000	4633	4731	407845	11.6	20502	22083	1150156	
2001	5615	5543	518037	10.7	20465	22630	1197354	
2002	6540	6524	582500	11.2	22333	23528	1258182	
2003	6774	6814	841235	8.1	23703	24828	1451930	
2004	6255	6421	823205	7.8	23703	24676	1701793	508.3
2005	6045	6114	745610	8.2	23703	23557	1682643	479.7
2006	6095	6229	648854	9.6	23703	24514	1776377	466.7
2007	6105	6485	600463	10.8	23703	24405	2068220	461.7
2008	7033	6823	573361	11.9	24148	23375	2125000	341.2
2009	7210	7091	644636	11.0	21769	21942	1959107	356.1
2010	7449	7283	693619	10.5	24195	24136	1774706	422.0

Table 9: Fall multi - species survey exploitable and pre - recruit biomass indices with confidence intervals and mean catch by year for Divisions 3LNO (The multi-species survey was incomplete in 2004 and 2006).

YEAR	EXPLOITABLE CRAB IN 3LNO				PRE - RECRUIT CRAB IN 3LNO			
	BIOMASS (t)			MEAN (kg/set)	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower		ESTIMATE	Upper	Lower	
1995	31839	40594	23083	3.09	17719	23358	12081	1.72
1996	37461	45018	29903	3.68	26733	36837	16629	2.62
1997	24527	30227	18827	2.39	16266	61740	-29207	1.58
1998	34288	42552	26024	3.33	21015	40946	1084	2.04
1999	20822	25163	16480	2.04	10940	15694	6186	1.07
2000	15507	19841	11172	1.53	10416	13969	6863	1.03
2001	24501	31053	17950	2.38	10159	13405	6913	0.99
2002	19304	25312	13297	1.88	5615	8519	2711	0.55
2003	15363	19789	10937	1.50	8234	14106	2362	0.80
2004	*9638*	*15675*	*3601*	*1.04*	*3831*	*9389*	*-1727*	*0.41*
2005	15725	27161	4288	1.53	4582	7095	2069	0.45
2006	*5027*	*6541*	*3513*	*0.49*	*2637*	*3865*	*1409*	*0.26*
2007	9711	14600	4822	0.94	8072	11083	5062	0.78
2008	14991	19360	10622	1.46	16457	23298	9615	1.60
2009	22397	31968	12826	2.18	19054	26373	11735	1.85
2010	18376	27607	9146	1.79	18094	28646	7542	1.76

Table 10: Annual Total Allowable Catch, Landings, Effort and Catch Per Unit Effort for Inshore and Offshore Subdivision 3Ps.

YEAR	INSHORE 3Ps				OFFSHORE 3Ps			
	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	LOGBOOK CPUE (kg/trap)	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1995	1200	1035	161719	6.4	525	894	45846	
1996	1350	1309	73955	17.7	1700	1665	99701	
1997	2400	2305	187398	12.3	2200	2370	117910	
1998	2500	3367	333366	10.1	3700	3257	134033	
1999	3701	3598	342667	10.5	4298	4307	177975	
2000	3300	3501	350100	10.0	4400	4386	212913	
2001	3200	3436	279350	12.3	4400	4403	271790	
2002	3200	3280	410000	8.0	4400	4357	360083	
2003	2520	2369	415614	5.7	3565	3750	451807	
2004	1630	1302	372000	3.5	2765	3418	421975	235.7
2005	1300	705	207353	3.4	2800	2468	398065	174.4
2006	975	781	200256	3.9	2070	2324	309867	195.9
2007	975	1146	216226	5.3	2270	2816	375467	217.5
2008	1128	1426	171807	8.3	3230	3097	279009	284.8
2009	1500	1939	164322	11.8	3780	3620	287302	320.5
2010	1900	2161	158897	13.6	4305	3865	336087	309.3

Table 11: Spring multi - species survey exploitable and pre - recruit biomass indices with confidence intervals and mean catch by year for Subdivision 3Ps (The multi - species survey was incomplete in 2006).

YEAR	EXPLOITABLE CRAB IN 3Ps				PRE - RECRUIT CRAB IN 3Ps			
	BIOMASS (t)			MEAN (kg/set)	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower		ESTIMATE	Upper	Lower	
1996	4535	7943	1128	1.88	1839	3582	96	0.76
1997	1119	1691	547	0.47	291	522	59	0.12
1998	1476	2273	679	0.61	601	1086	116	0.25
1999	2528	4429	626	1.05	324	466	181	0.13
2000	927	1390	465	0.38	235	443	26	0.10
2001	500	801	199	0.21	311	614	7	0.13
2002	427	618	236	0.18	309	478	140	0.13
2003	433	1167	-301	0.18	97	196	-1	0.04
2004	211	308	114	0.09	209	336	82	0.09
2005	503	803	203	0.21	437	630	244	0.18
2006	*18*	*74*	*-37*	*0.03*	*51*	*122*	*-21*	*0.07*
2007	246	411	81	0.10	780	1768	-209	0.32
2008	379	570	189	0.16	1058	2966	-849	0.44
2009	935	1599	272	0.39	1422	2382	462	0.59
2010	790	1313	268	0.33	460	1038	-117	0.19

Table 12: Annual Total Allowable Catch, Landings, Effort and Catch Per Unit Effort for Inshore and Offshore Division 4R3Pn.

YEAR	INSHORE 4R3Pn				OFFSHORE 4R3Pn			
	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	LOGBOOK CPUE (kg/trap)	TAC (t)	LANDINGS (t)	EFFORT (trap hauls)	VMS CPUE (kg/hr)
1998	1310	1067	197593	5.4				
1999	690	988	161967	6.1	645	629	149762	
2000	785	954	190800	4.9	645	674	134800	
2001	909	1026	190000	5.6	635	649	147500	
2002	904	878	100920	8.4	845	977	195400	
2003	1050	954	117778	8.0	845	608	168889	
2004	1016	877	139206	6.3	838	584	182500	128.3
2005	1000	511	81111	6.3	845	348	108750	123.7
2006	860	460	85185	5.4	675	79	22571	99.3
2007	750	368	85581	4.3	540	194	77600	98.9
2008	718	250	65789	3.7	540	131	37429	92.5
2009	483	199	53784	3.8	418	88	31429	82.8
2010	482	188	47000	4.0	418	33	6875	117.8

Table 13: Summer multi - species survey exploitable and pre - recruit biomass indices with confidence intervals and mean catch by year for Divisions 4R3Pn.

YEAR	EXPLOITABLE CRAB IN 4R3Pn				PRE - RECRUIT CRAB IN 4R3Pn			
	BIOMASS (t)			MEAN (kg/set)	BIOMASS (t)			MEAN (kg/set)
	ESTIMATE	Upper	Lower		ESTIMATE	Upper	Lower	
2004	111	292	-70	0.15	195	917	-527	0.26
2005	82	273	-109	0.15	14	74	-46	0.02
2006	180	431	-72	0.22	46	116	-24	0.06
2007	92	261	-77	0.11	54	260	-151	0.07
2008	177	555	-202	0.22	52	121	-17	0.06
2009	229	1099	-640	0.28	74	337	-189	0.09
2010	80	188	-28	0.10	18	52	-16	0.02

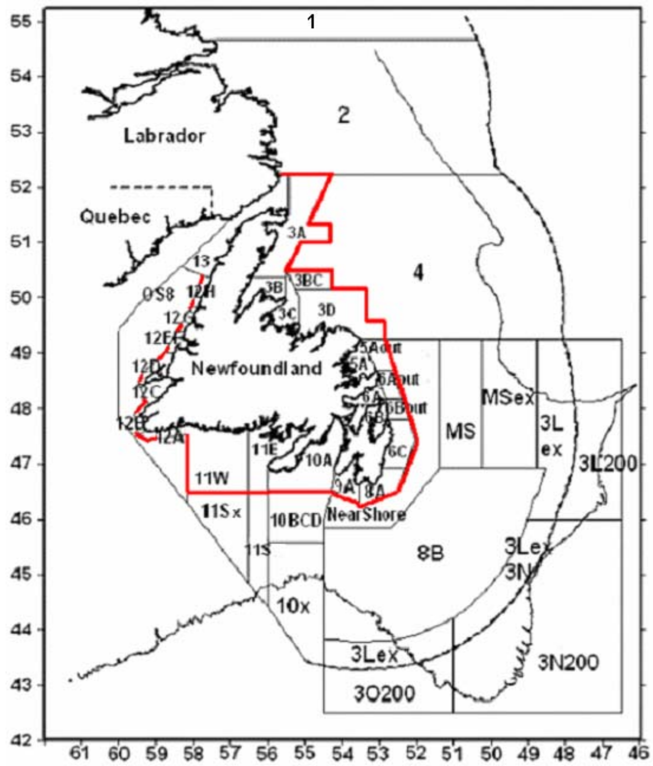


Figure 1. Newfoundland and Labrador Snow Crab Management areas. (Red line shows division of inshore vs. offshore CMAs).

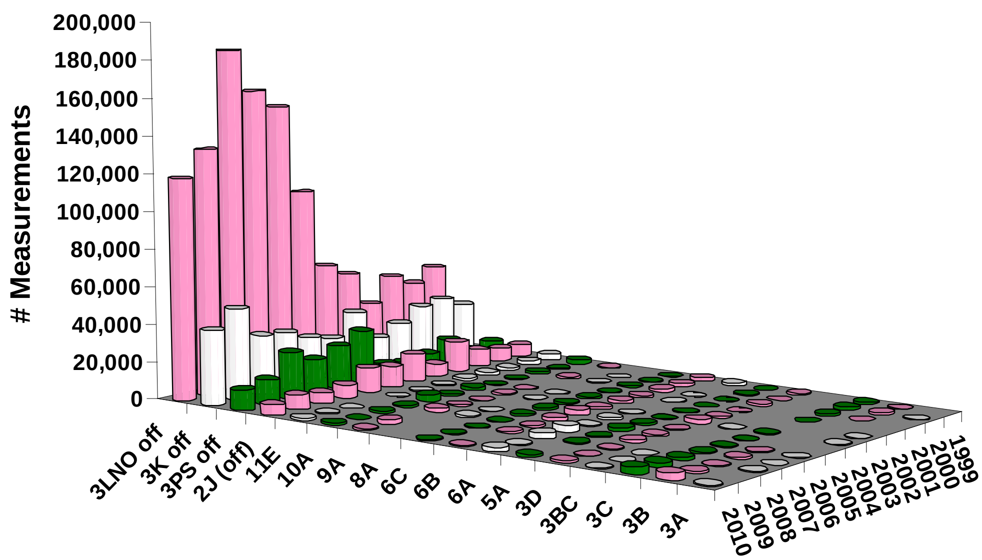


Figure 2: Observer sampling by crab management area (CMA) and year. Data pooled for offshore crab management areas in each Division.

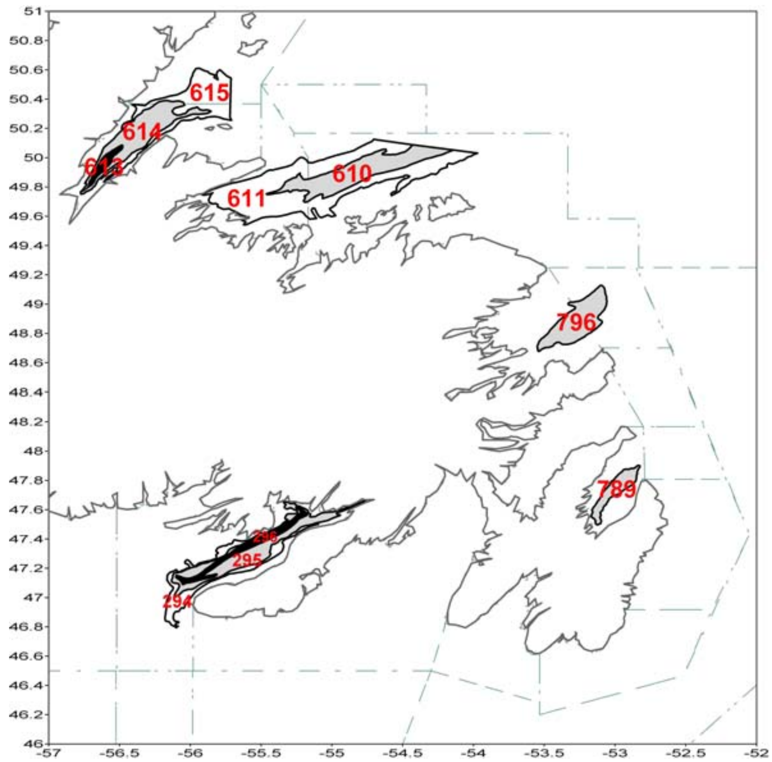


Figure 3: Strata sampled during DFO inshore trap and trawl surveys.

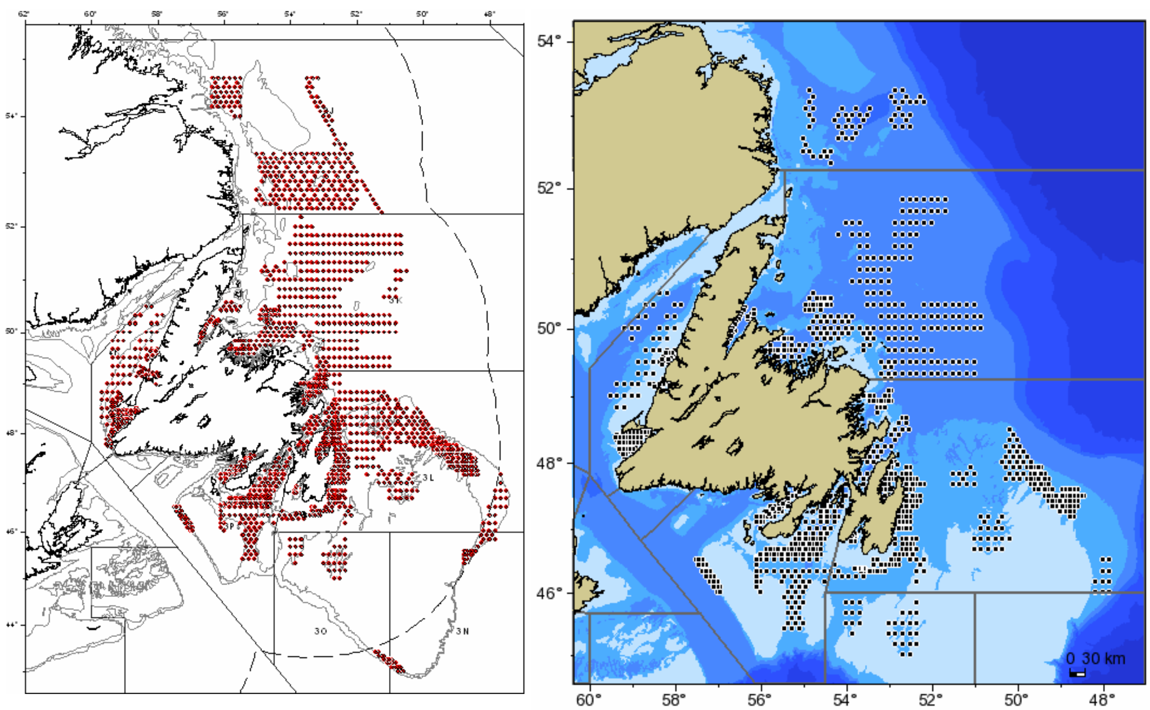


Figure 4: Industry – DFO Collaborative Post-Season trap survey design (left) and core stations used for data analyses (right).

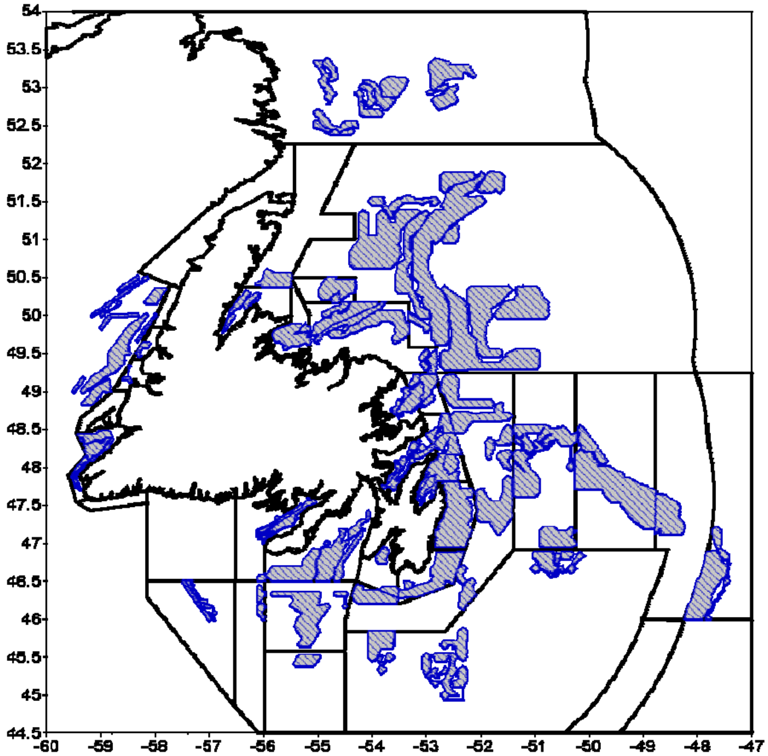


Figure 5: Stratification scheme used to derive biomass estimates from the Collaborative Post-Season trap survey.

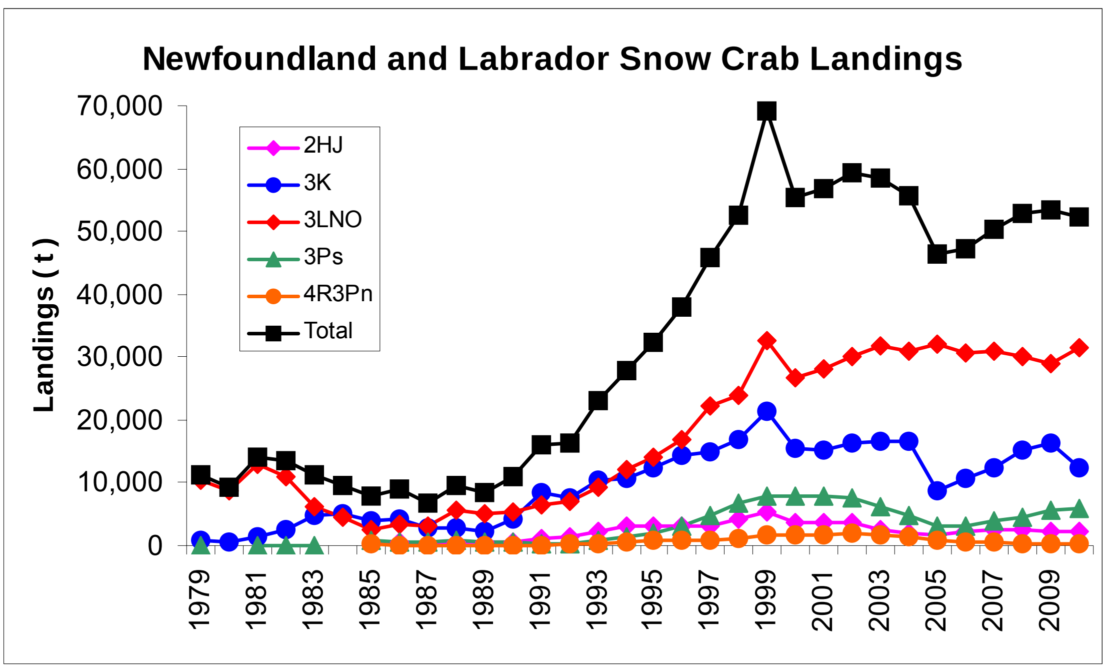


Figure 6: Trends in landings by NAFO Division and in total.

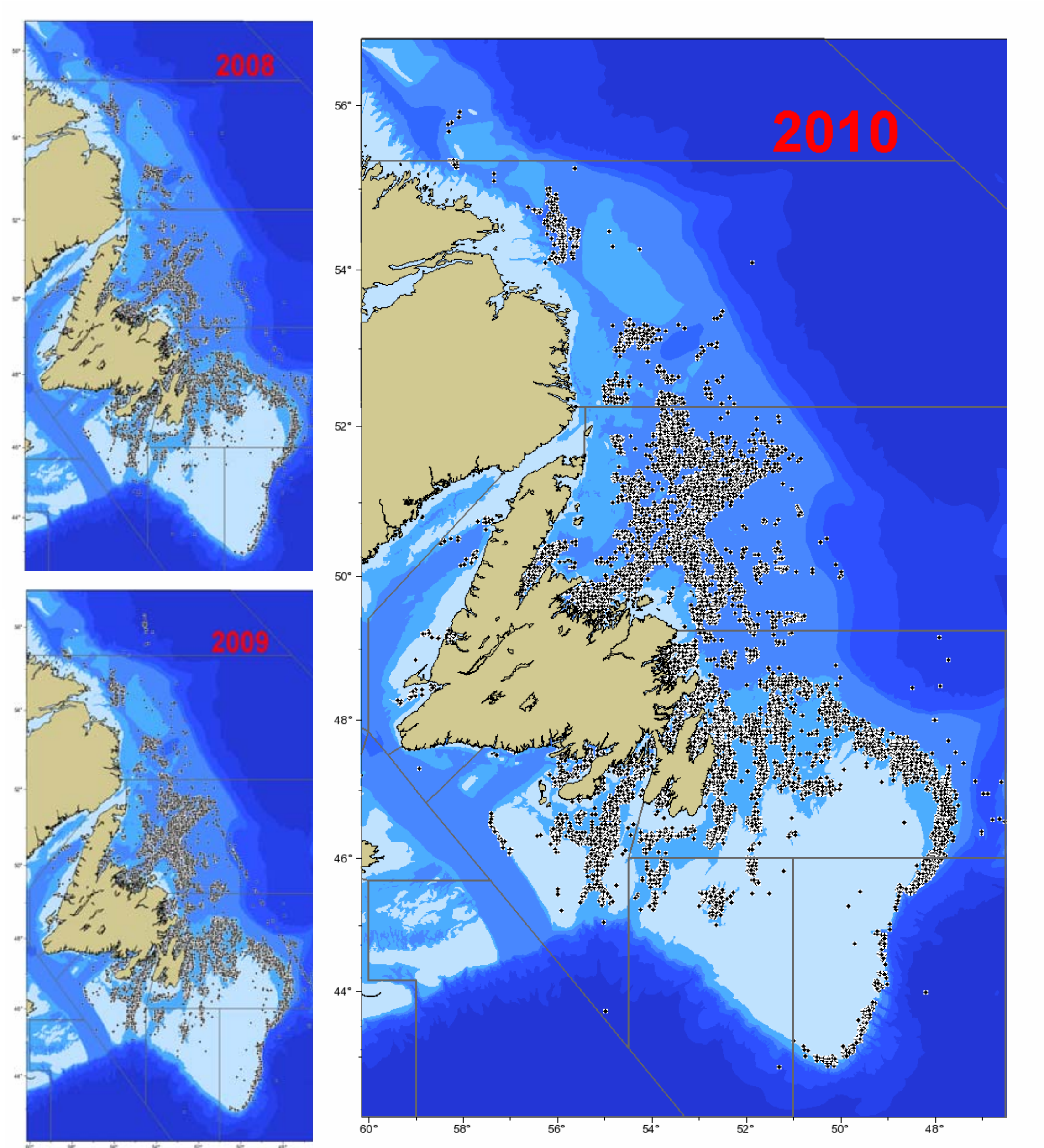


Figure 7: Spatial distribution of commercial fishing effort (set locations) during 2008 to 2010.

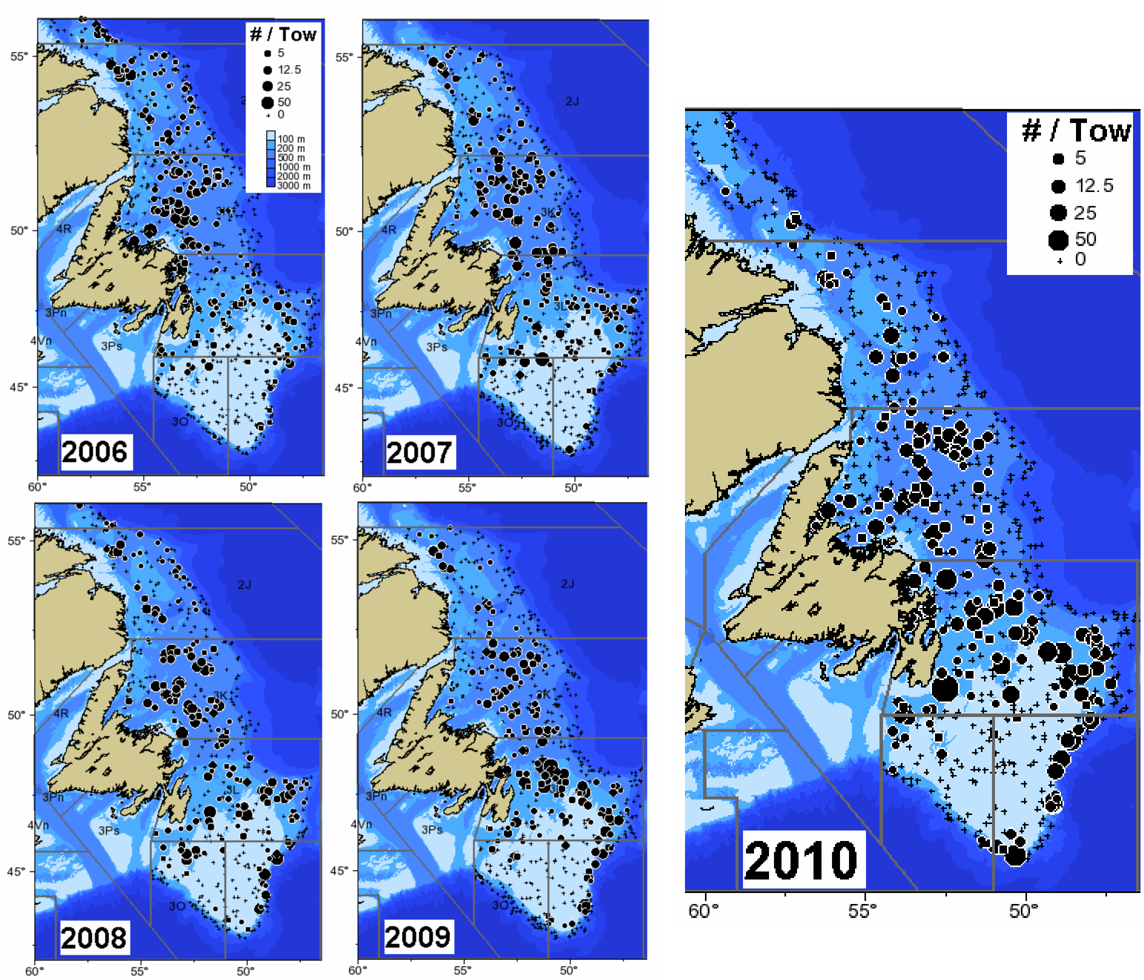


Figure 8: Distribution of exploitable males (> 94mm CW adults) from fall Div. 2HJ3KLNO bottom trawl surveys from 2006-2010.

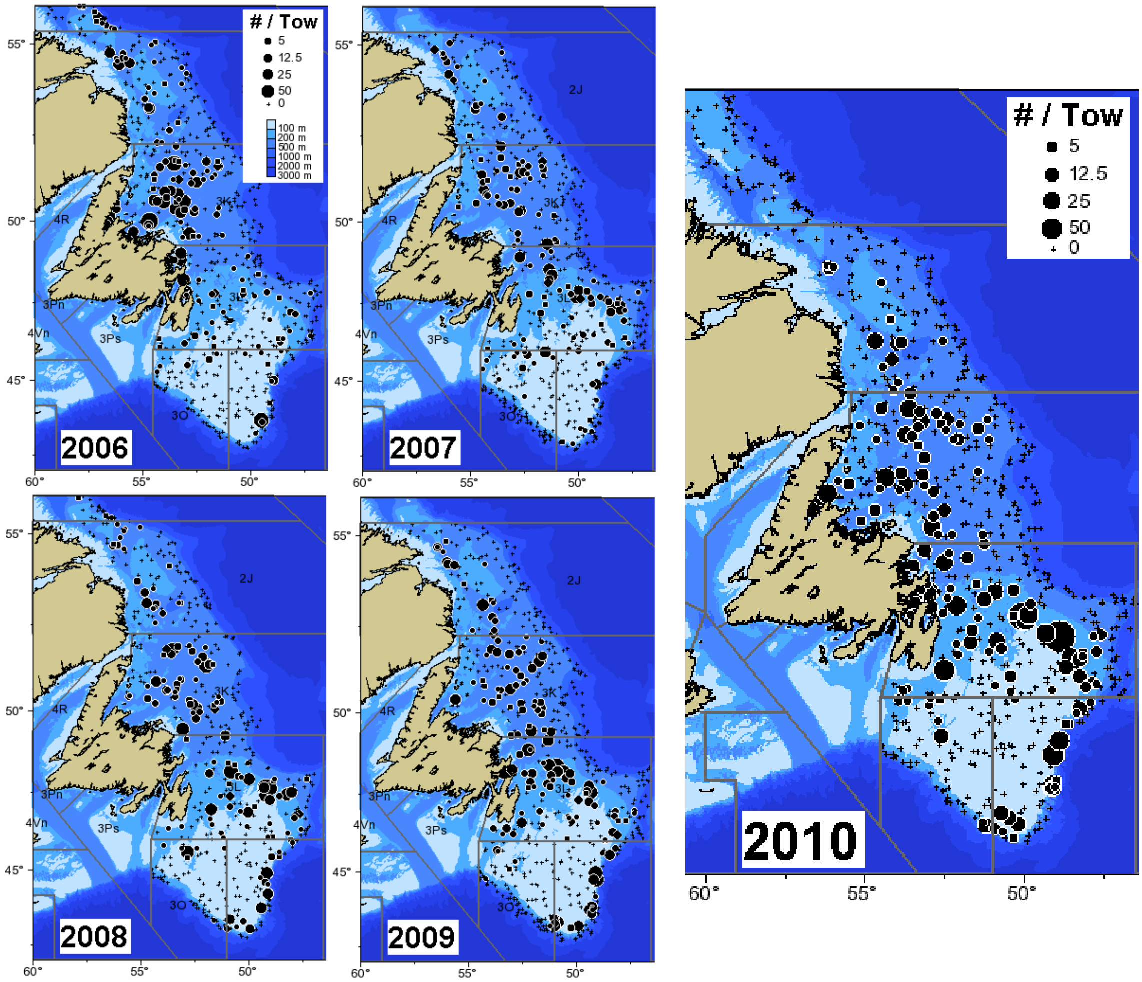


Figure 9: Distribution of pre-recruit males (> 75mm CW adolescents) from fall Div. 2HJ3KLNO bottom trawl surveys from 2006-2010.

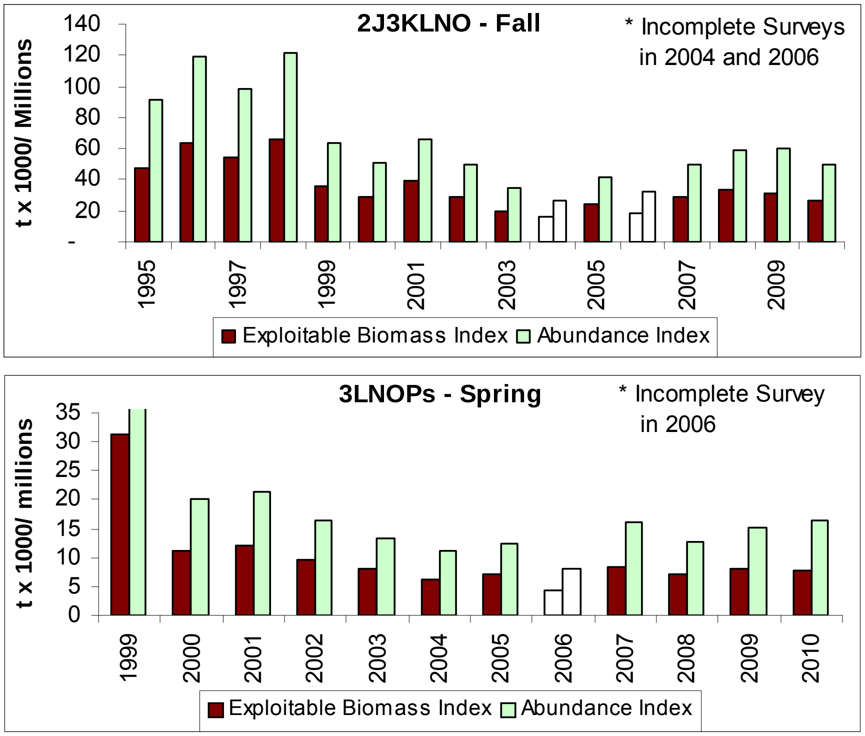


Figure 10: Trends in the trawl survey exploitable biomass and abundance indices for Div. 2J3KLNO during fall (above) and Div. 3LNOPs during spring (below).

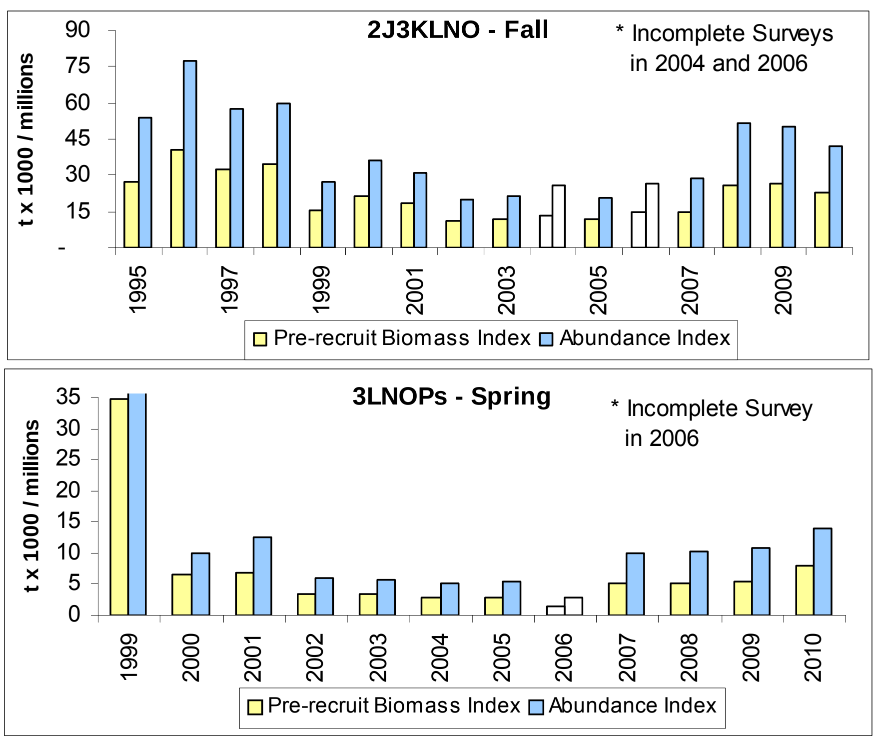


Figure 11: Trends in the trawl survey pre-recruit biomass and abundance indices for Div. 2J3KLNO during fall (above) and Div. 3LNOPs during spring (below).

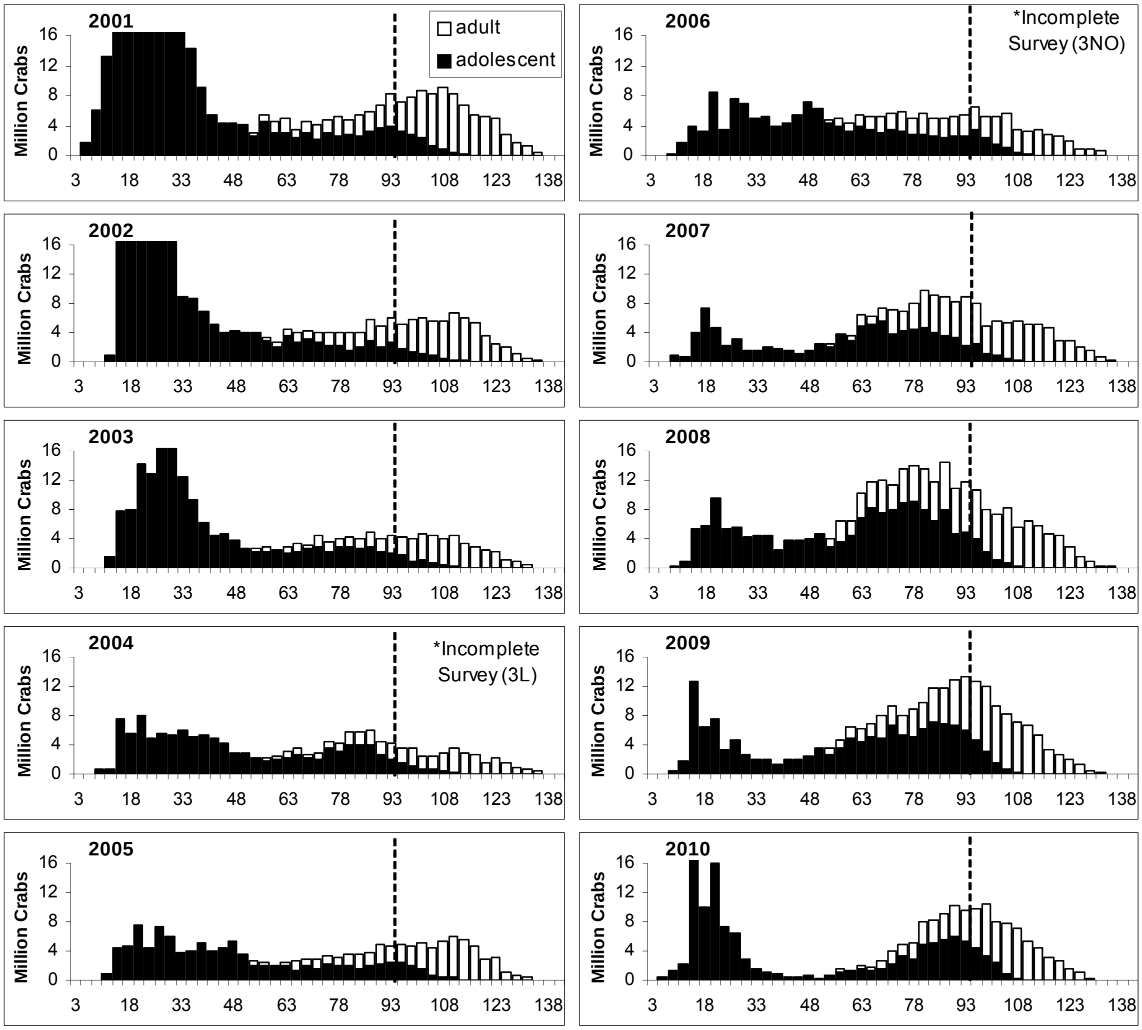


Figure 12: Abundance indices by carapace width for Div. 2J3KLNO juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line.

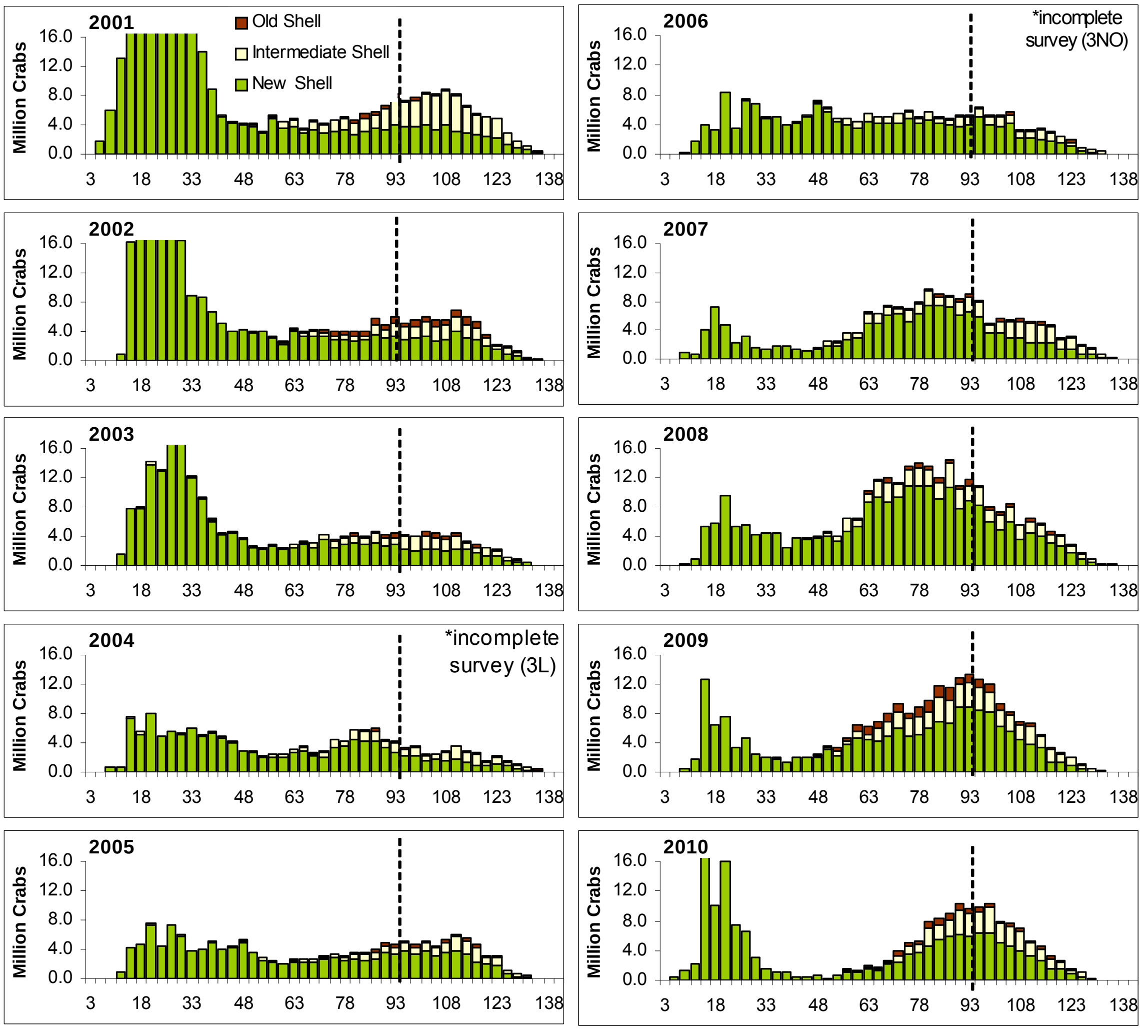


Figure 13: Abundance indices by carapace width and shell condition from fall trawl surveys for Div. 2J3KLNO. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line.

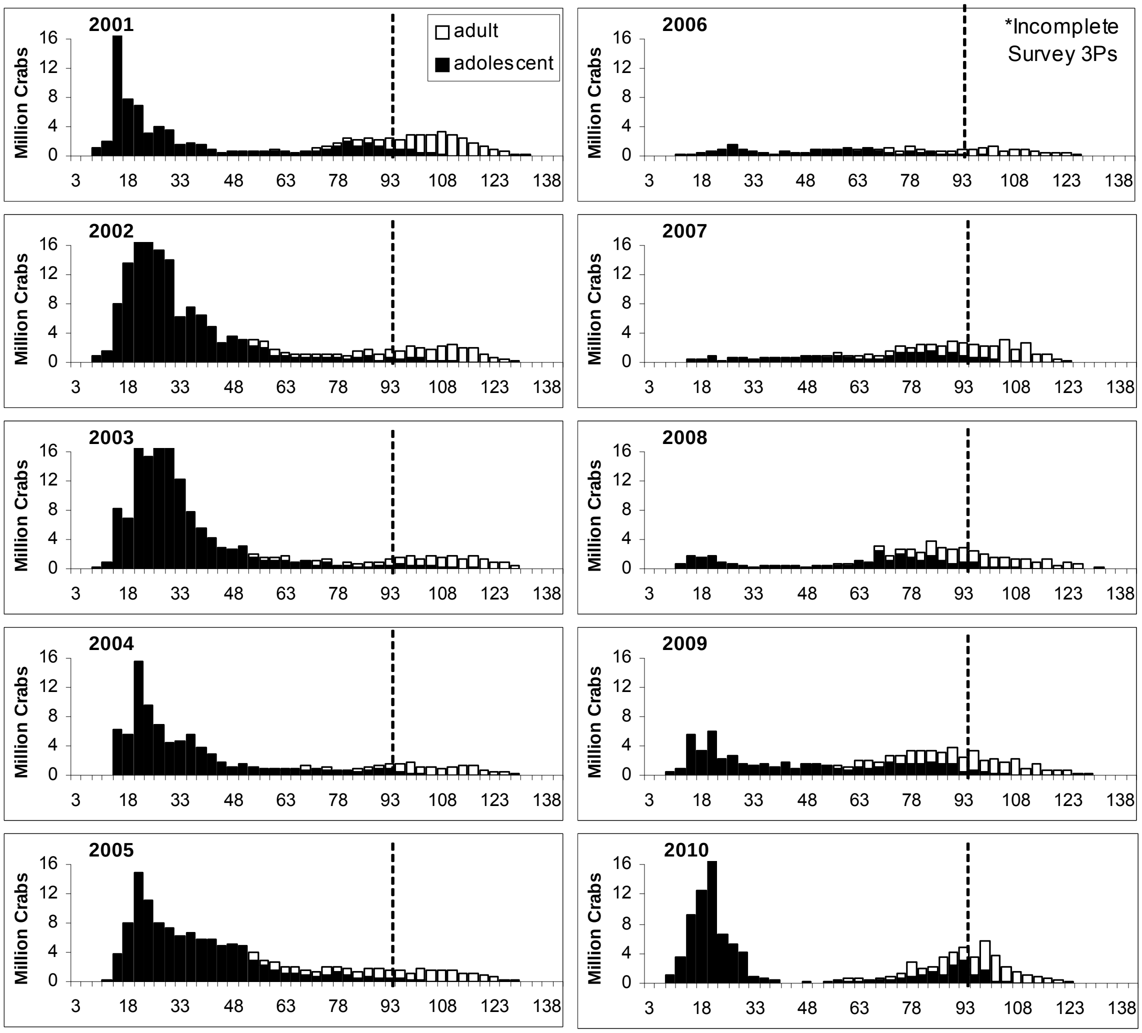


Figure 14: Abundance indices by carapace width for Div. 3LNOPs juveniles plus adolescents (dark bars) versus adults (open bars) from spring trawl surveys. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line. The survey was incomplete in 2006.

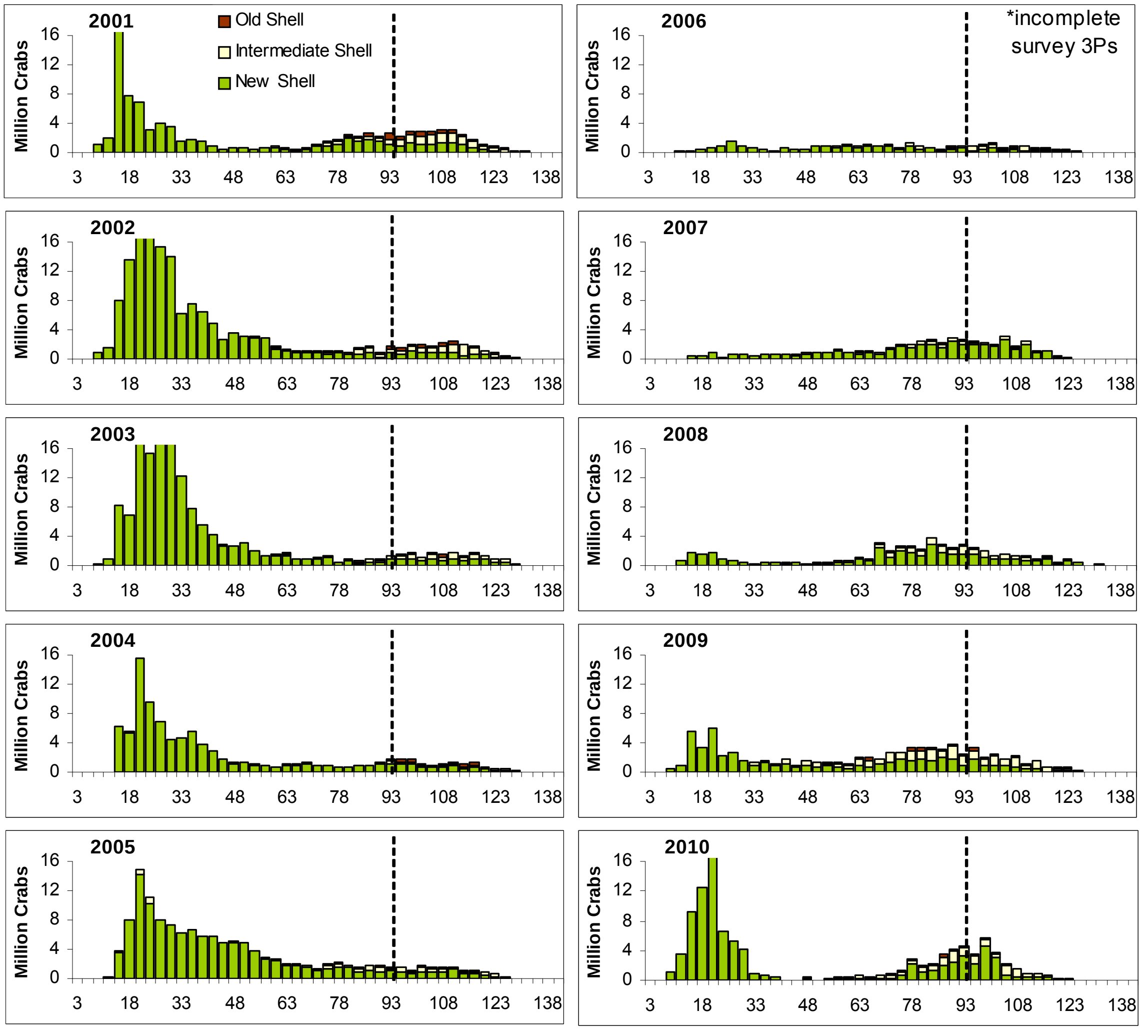


Figure 15: Abundance indices by carapace width and shell condition from spring trawl surveys for Div. 3LNOPs. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line. The survey was incomplete in 2006.

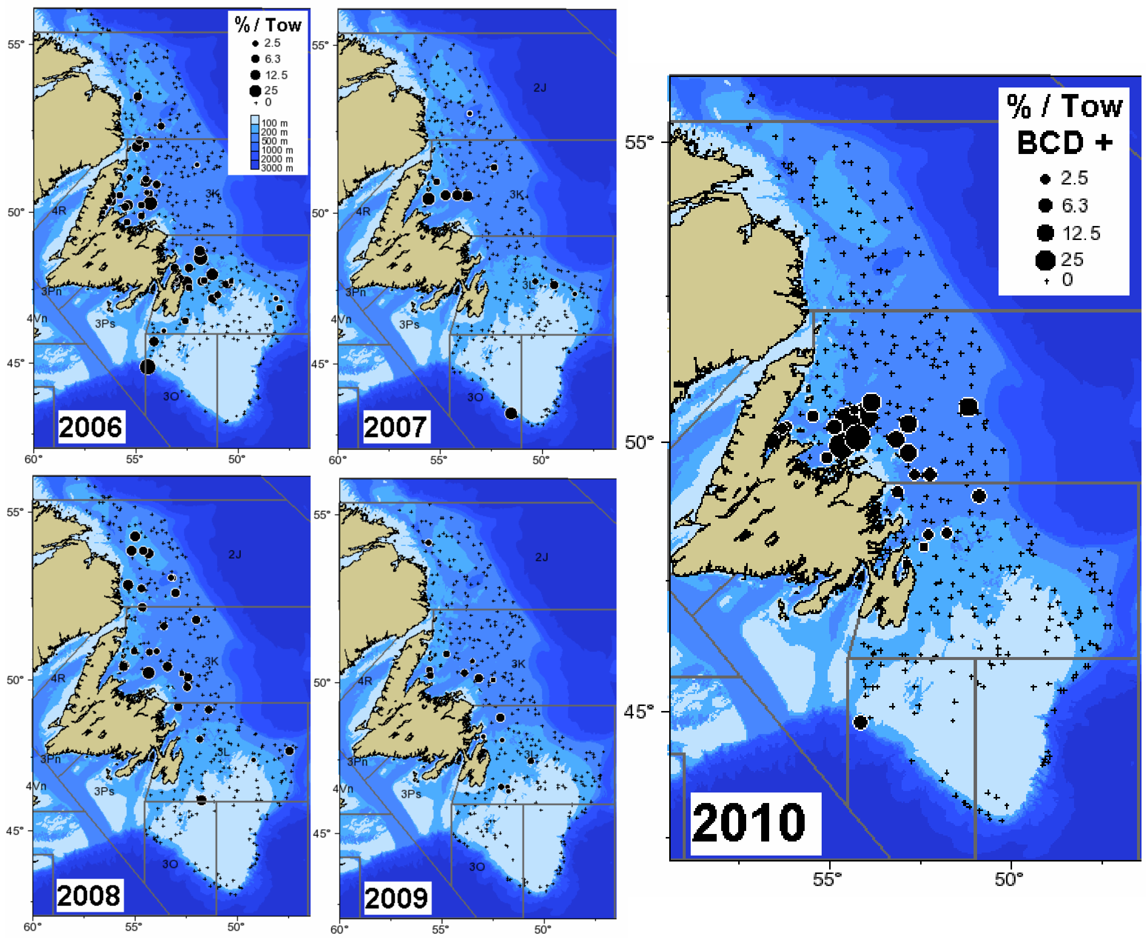


Figure 16: Percentage of BCD for crabs in trawl survey catches from 2006-2010.

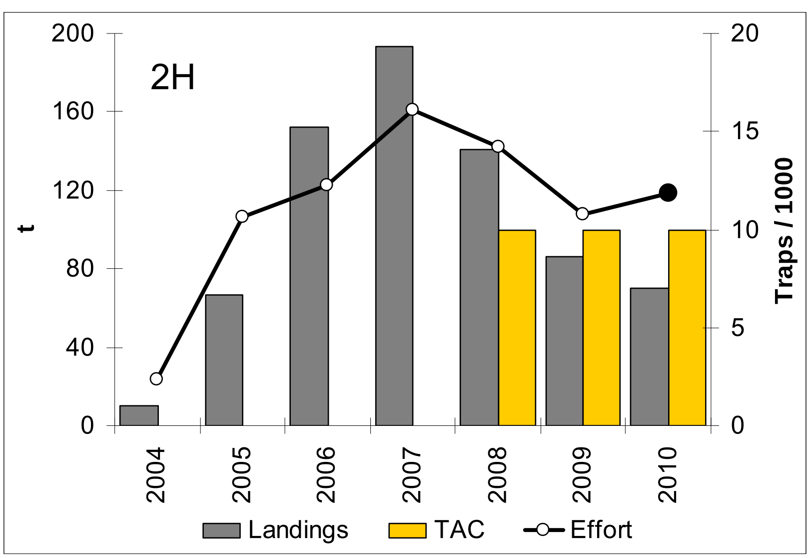


Figure 17: Trends in Div. 2H landings, TAC, and fishing effort.

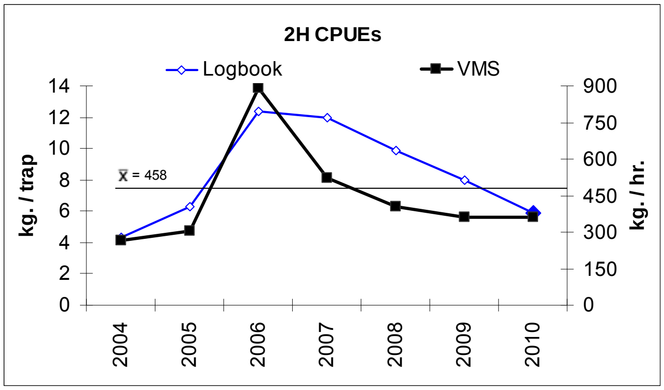


Figure 18: Trends in commercial logbook-based and VMS-based CPUE in the Div. 2H fishery. Solid black line denotes long-term VMS CPUE average.

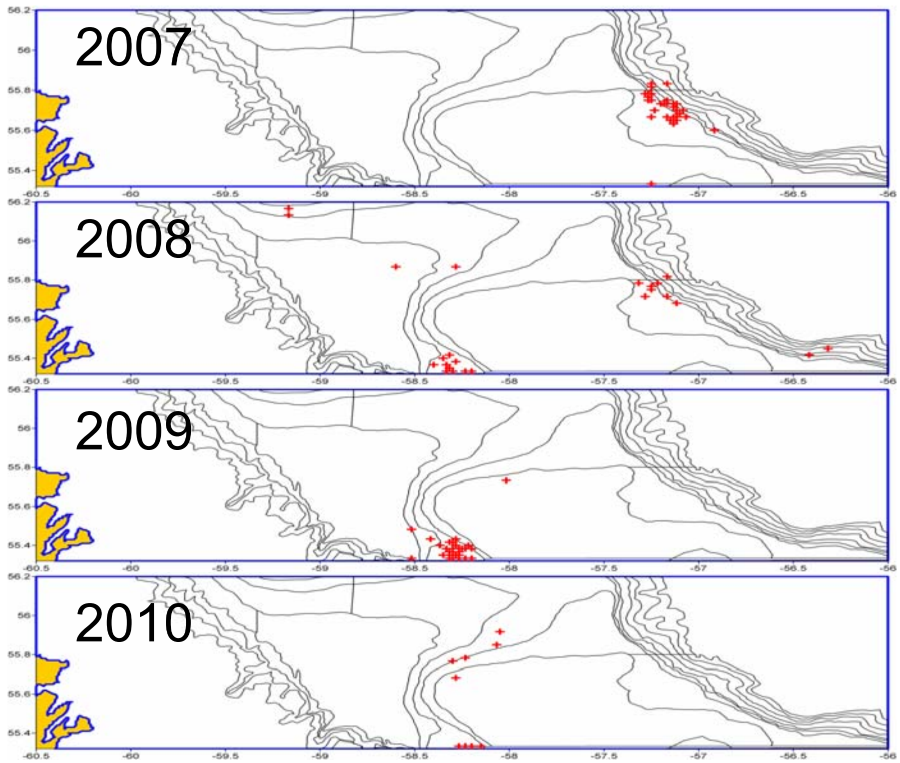


Figure 19: Spatial distribution of Div. 2H fishing effort by year.

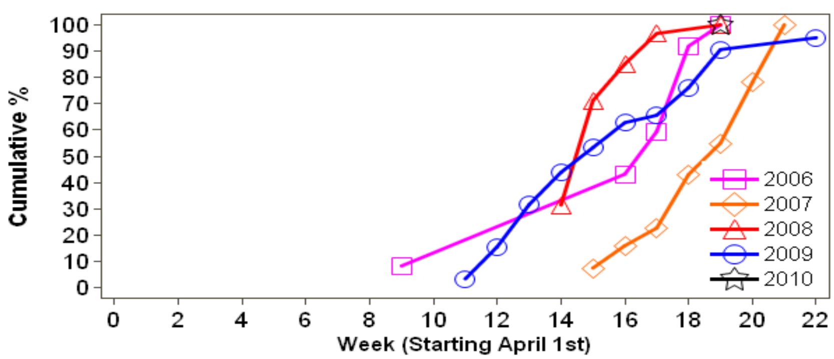


Figure 20: Seasonal trends in weekly fishing effort for Div. 2H during 2006-2010.

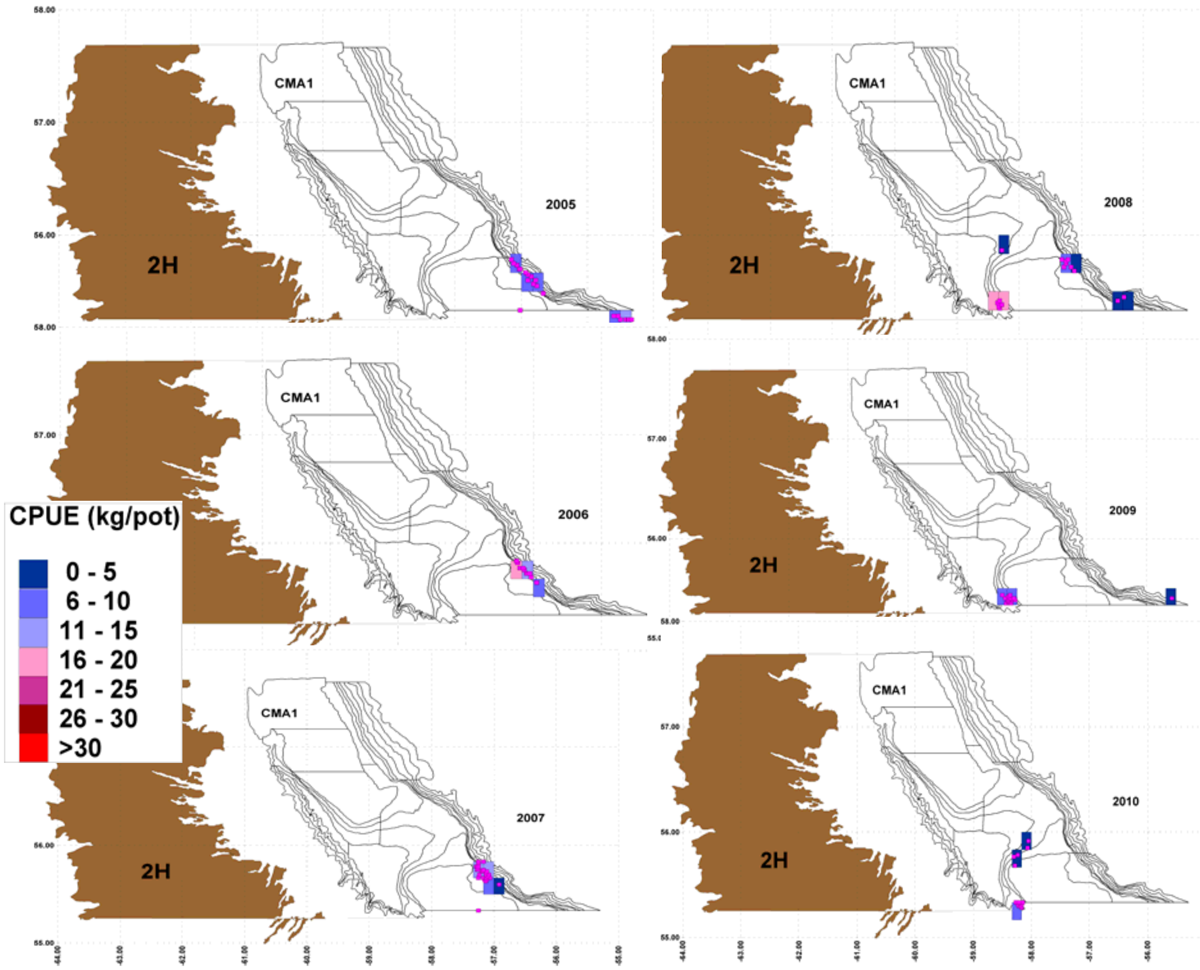


Figure 21: Spatial distribution of Div. 2H commercial CPUE by year.

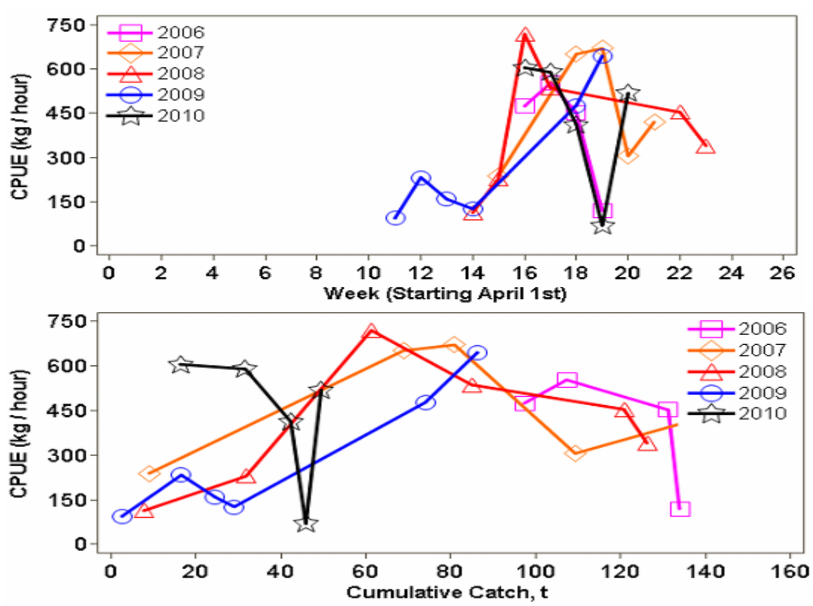


Figure 22: Seasonal trends in VMS-based CPUE for Div. 2H during 2006-2010; (above) by week, and (below) in relation to cumulative catch.

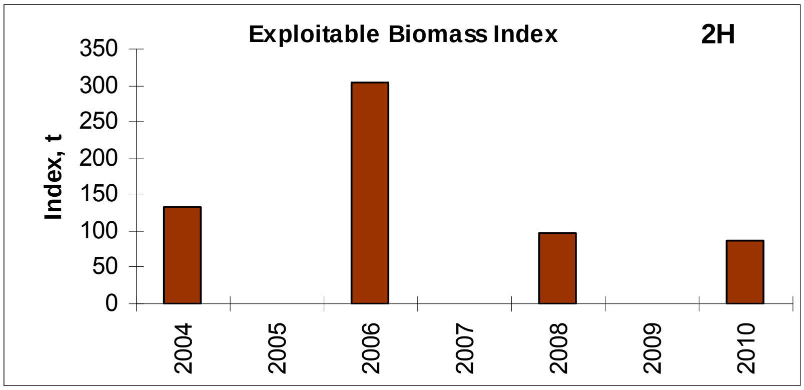


Figure 23: Trends in the Div. 2H fall trawl survey exploitable biomass index.

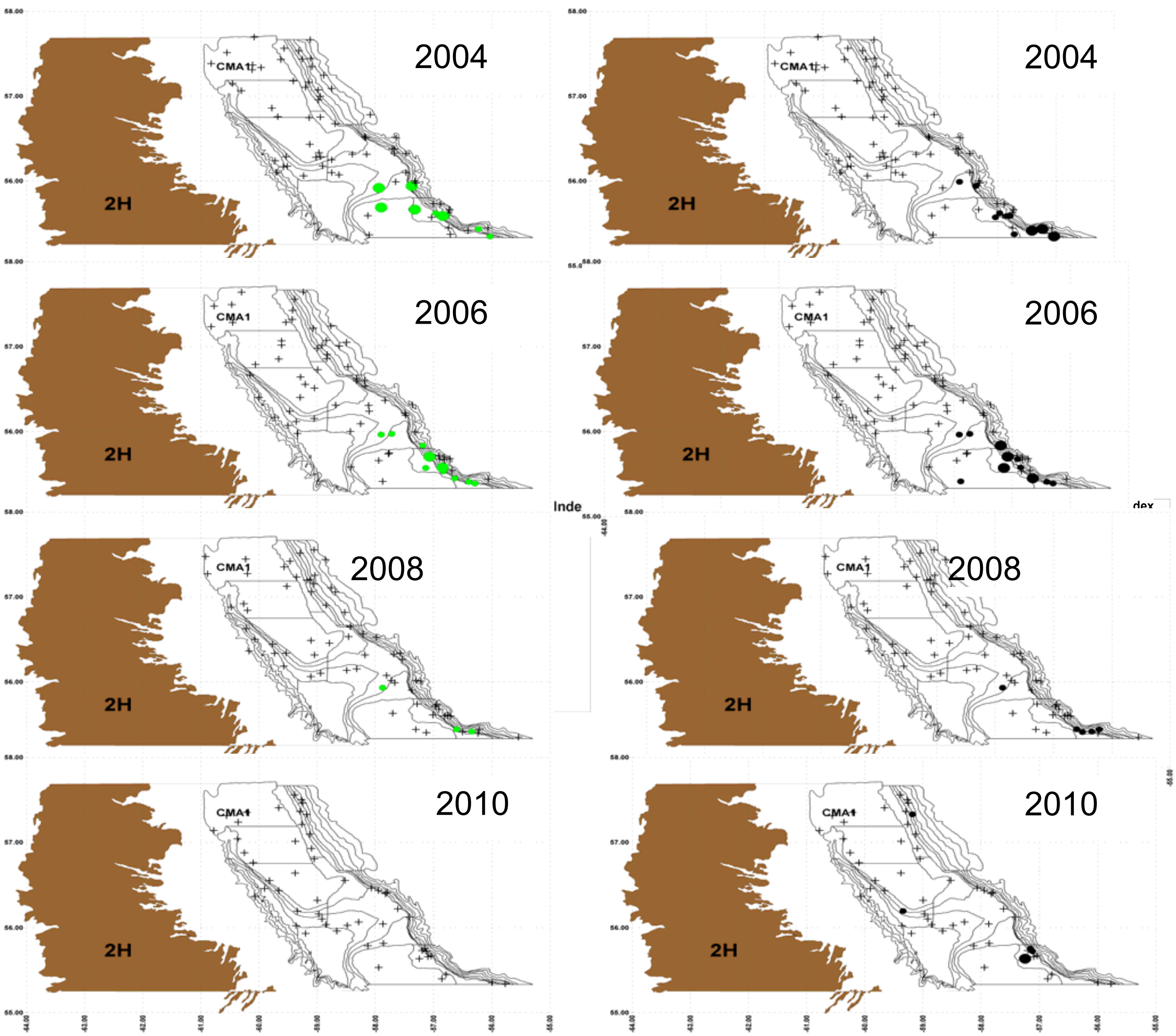


Figure 24: Spatial distribution of catches (number / set) of pre-recruit (left) and exploitable (right) males in the Div. 2H offshore trawl survey.

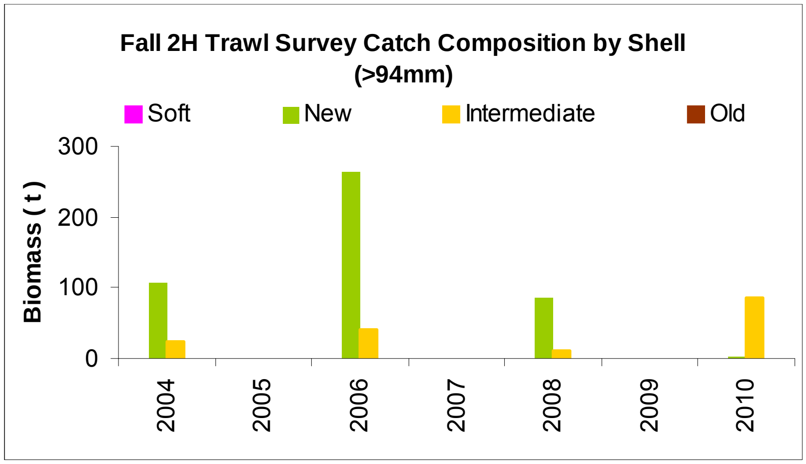


Figure 25: Trends, by shell condition, in legal-sized males for Div. 2H from fall trawl surveys.

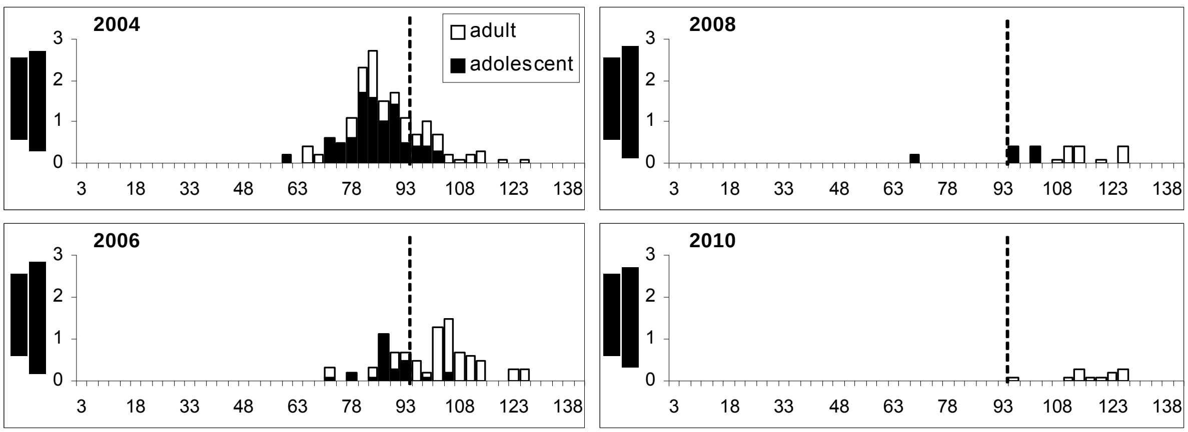


Figure 26: Abundance indices by carapace width for Div. 2H juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line.

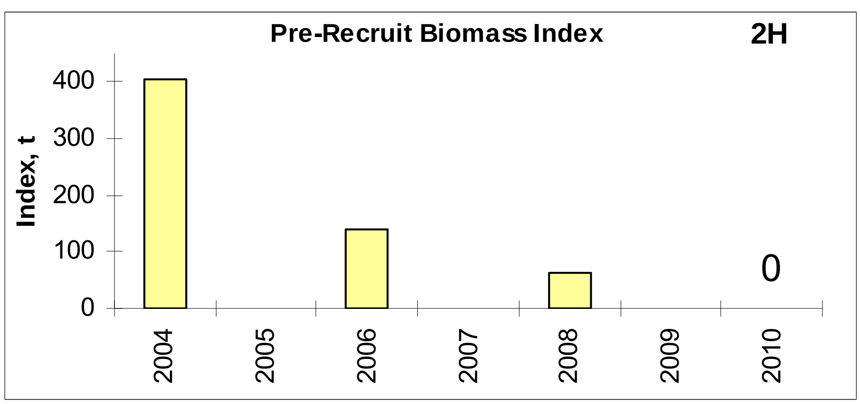


Figure 27: Trends in the Div. 2H fall trawl survey pre-recruit biomass index.

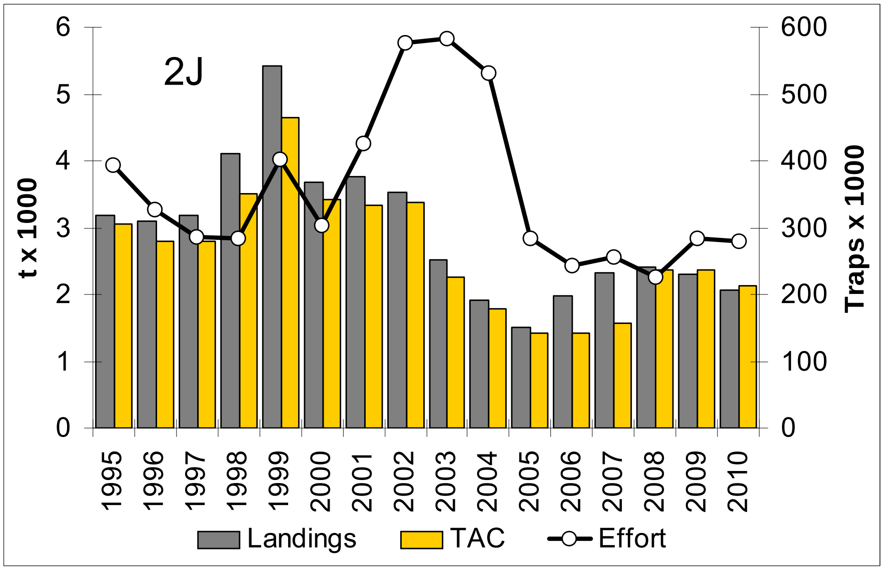


Figure 28: Trends in Div. 2J landings, TAC, and fishing effort.

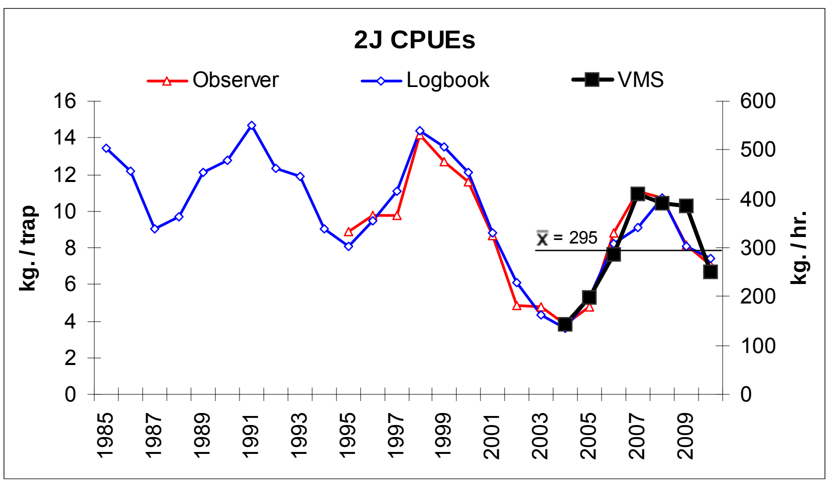


Figure 29: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Div. 2J fishery. Solid black line denotes long-term VMS CPUE average.

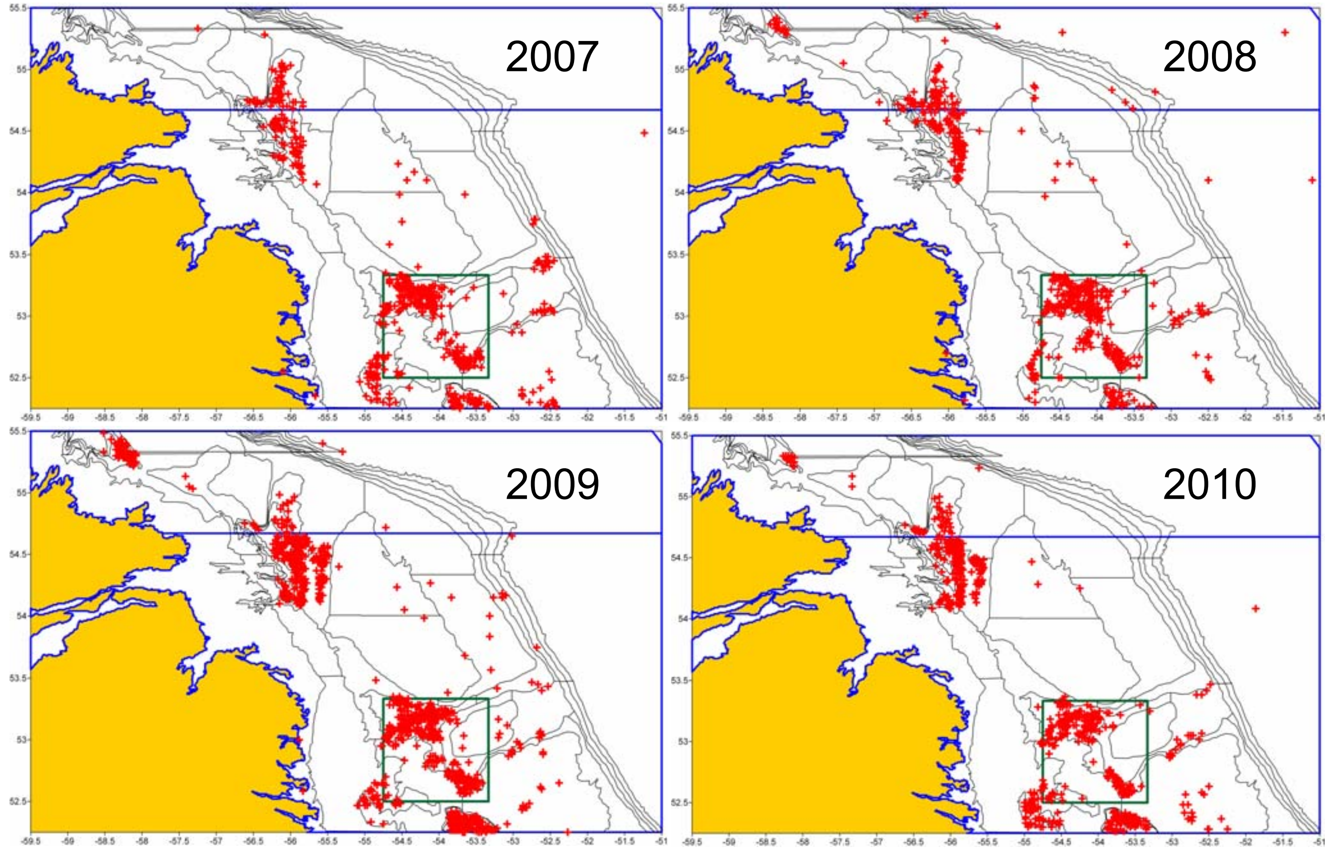


Figure 30: Spatial distribution of Div. 2J fishing effort by year.

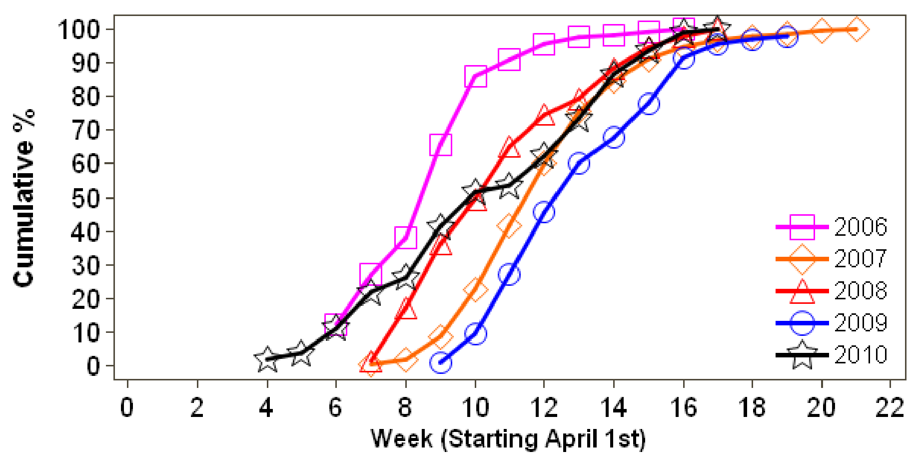


Figure 31: Seasonal trends in weekly fishing effort for Div. 2J during 2006-2010.

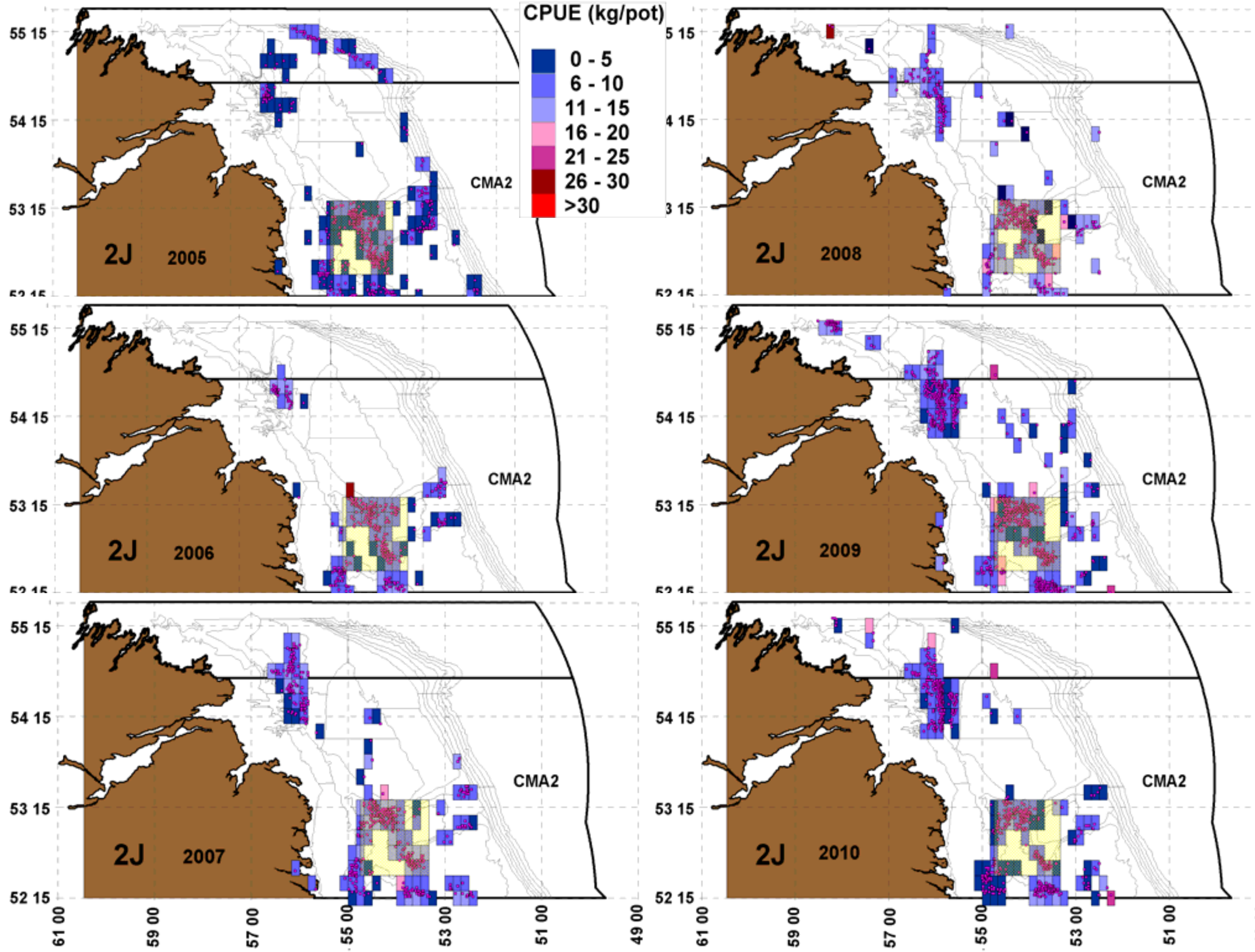


Figure 32: Spatial distribution of Div. 2J logbook CPUE.

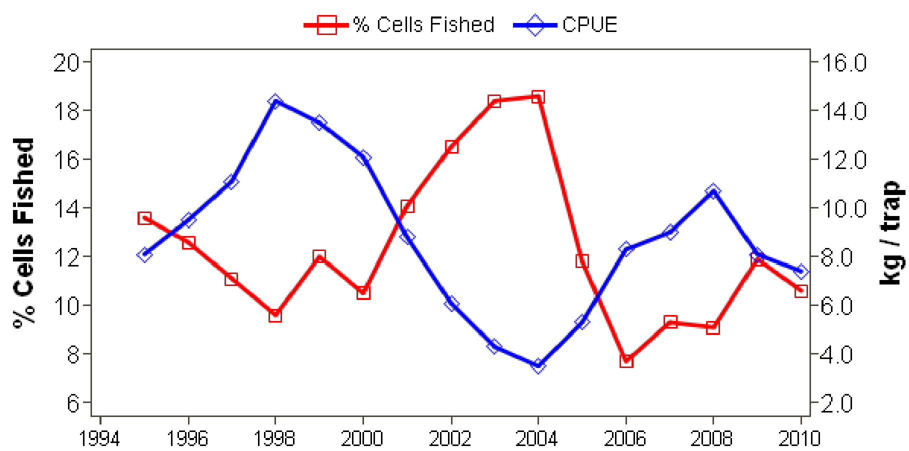


Figure 33: Trends in Div. 2J commercial CPUE vs. the percentage of 5' x 5' cells fished.

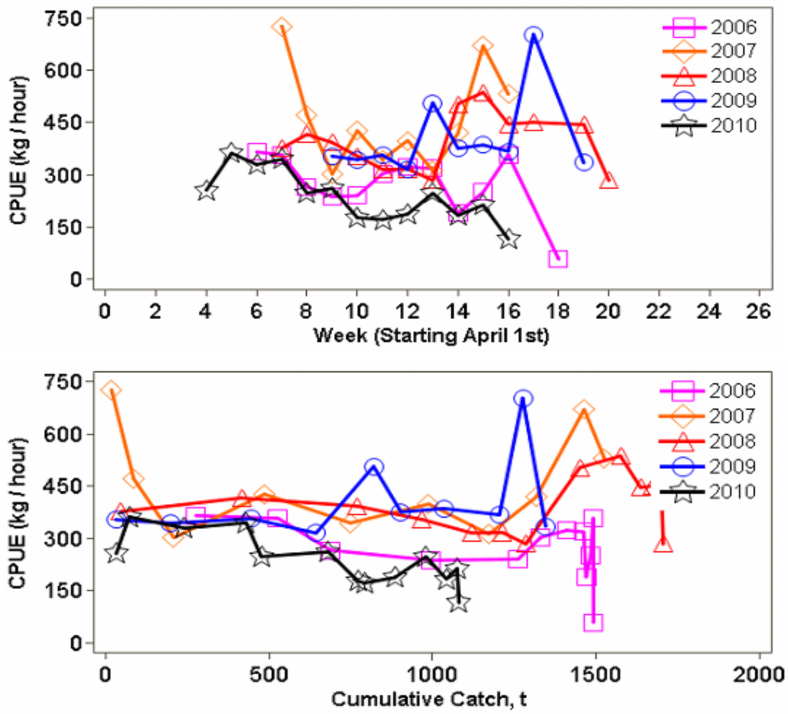


Figure 34: Seasonal trends in VMS-based CPUE for Div. 2J during 2006-2010; (above) by week, and (below) in relation to cumulative catch.

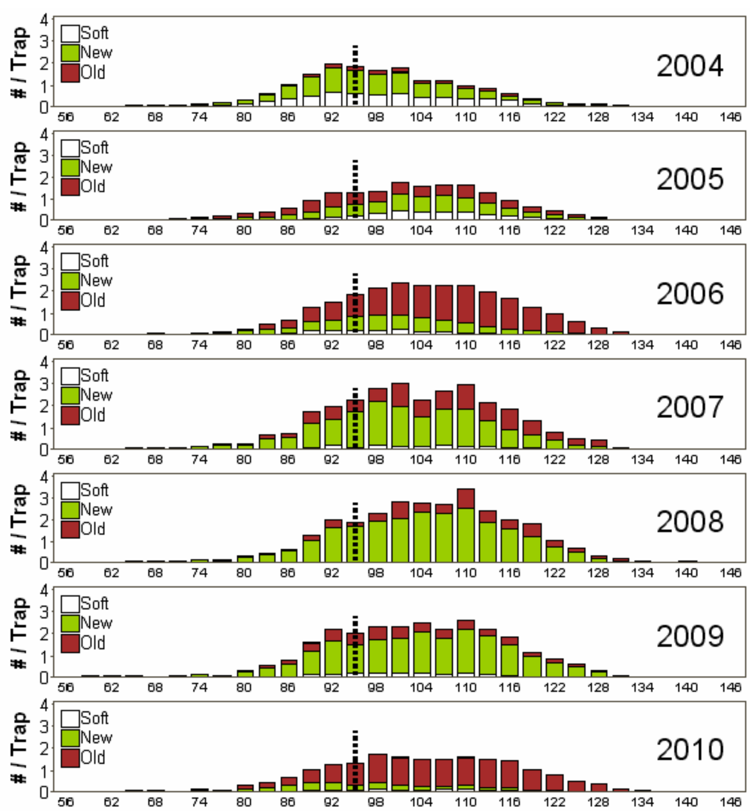


Figure 35: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Div. 2J. The vertical dashed line indicates the minimum legal size.

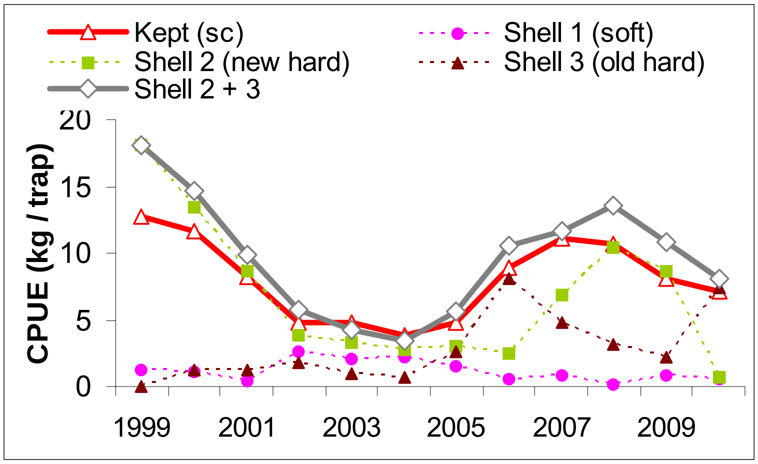


Figure 36: Trends in Division 2J observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

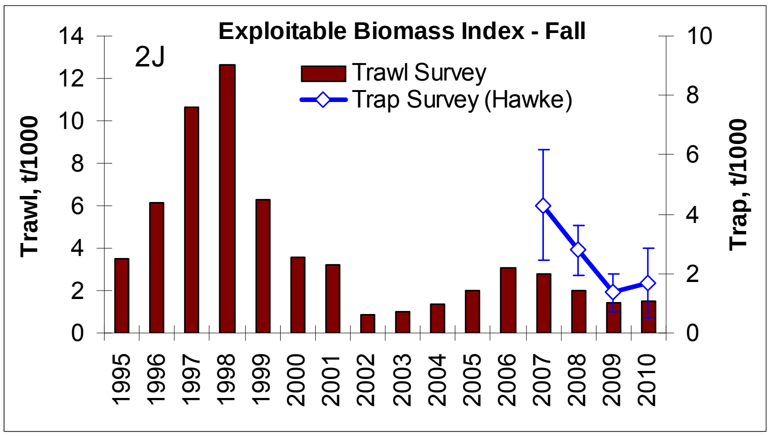


Figure 37: Trends in the Div. 2J fall trawl survey exploitable biomass index and the CPS trap survey biomass index.

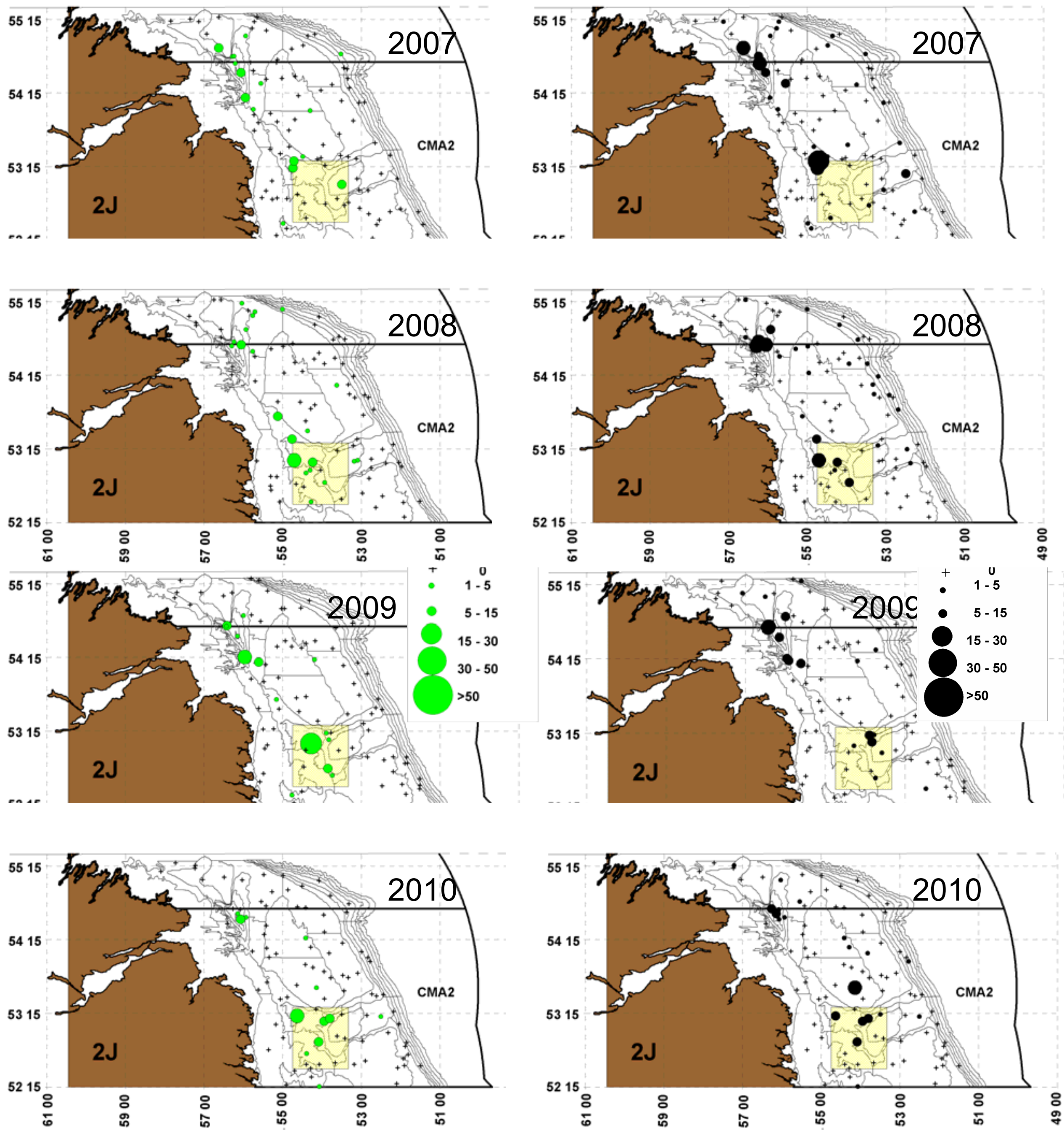


Figure 38: Spatial distribution of catches (number / set) of pre-recruit (left) and exploitable (right) males in the Div. 2J offshore trawl survey.

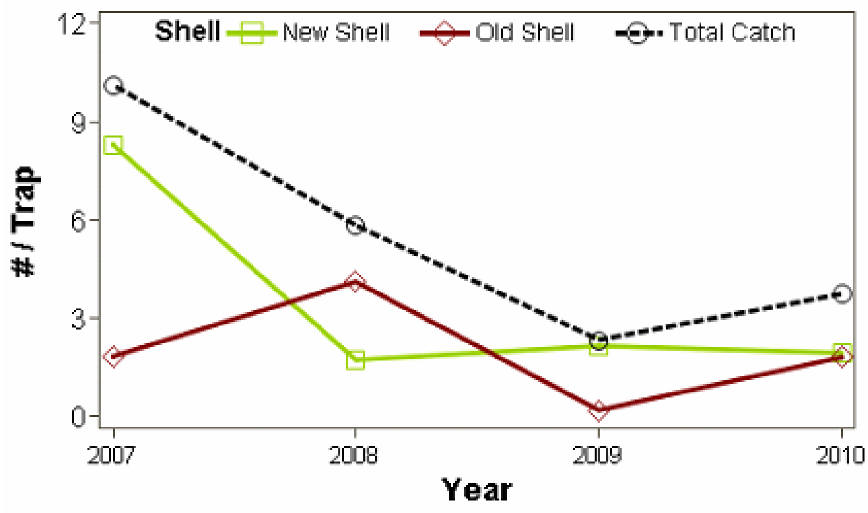


Figure 39: Trends in CPUE by shell condition for legal-sized crabs from core stations in the Div. 2J CPS trap survey.

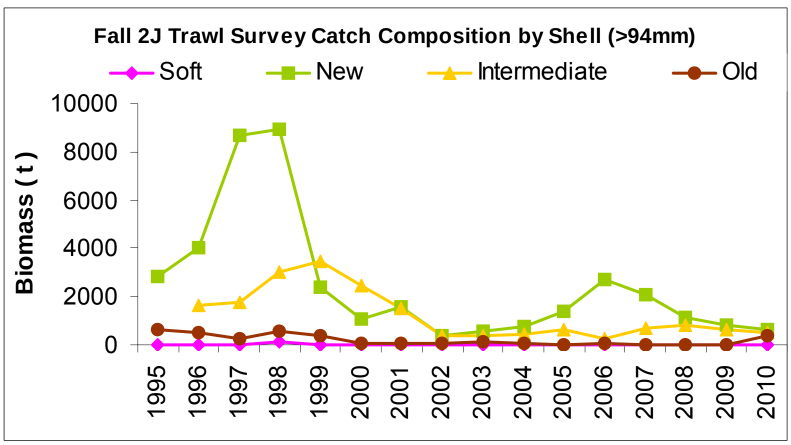
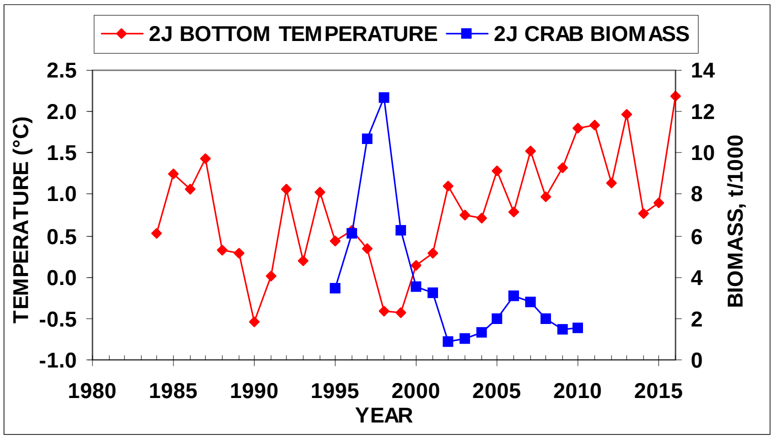


Figure 40: Trends, by shell condition, in biomass of legal-sized males for Div. 2J from fall trawl surveys.



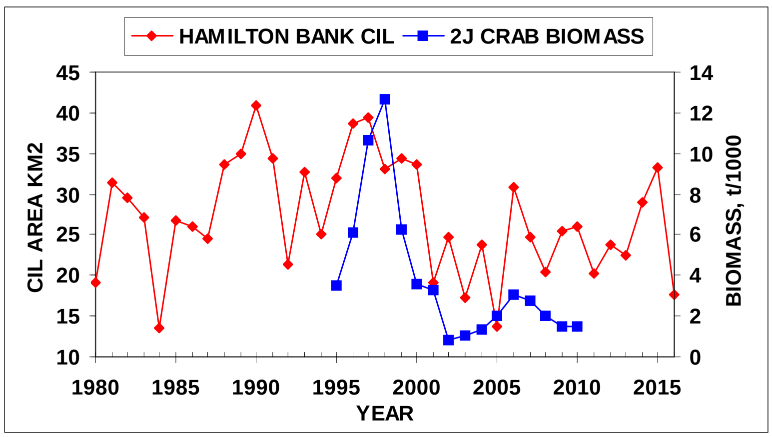


Figure 41: Trends in the Div. 2J exploitable biomass index vs. bottom temperature at a seven year lag (above) and vs. the spatial extent of the cold intermediate layer (below).

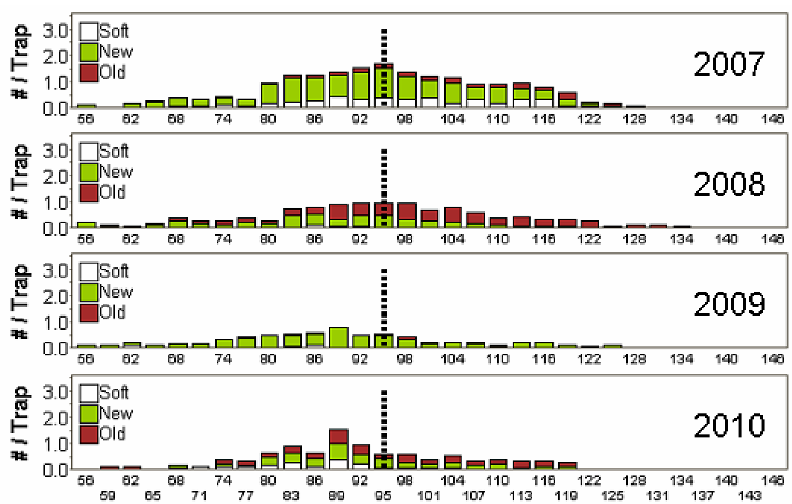


Figure 42: Trends in male carapace width distributions from core stations in the Div. 2J CPS trap survey. The vertical dashed line indicates the minimum legal size.

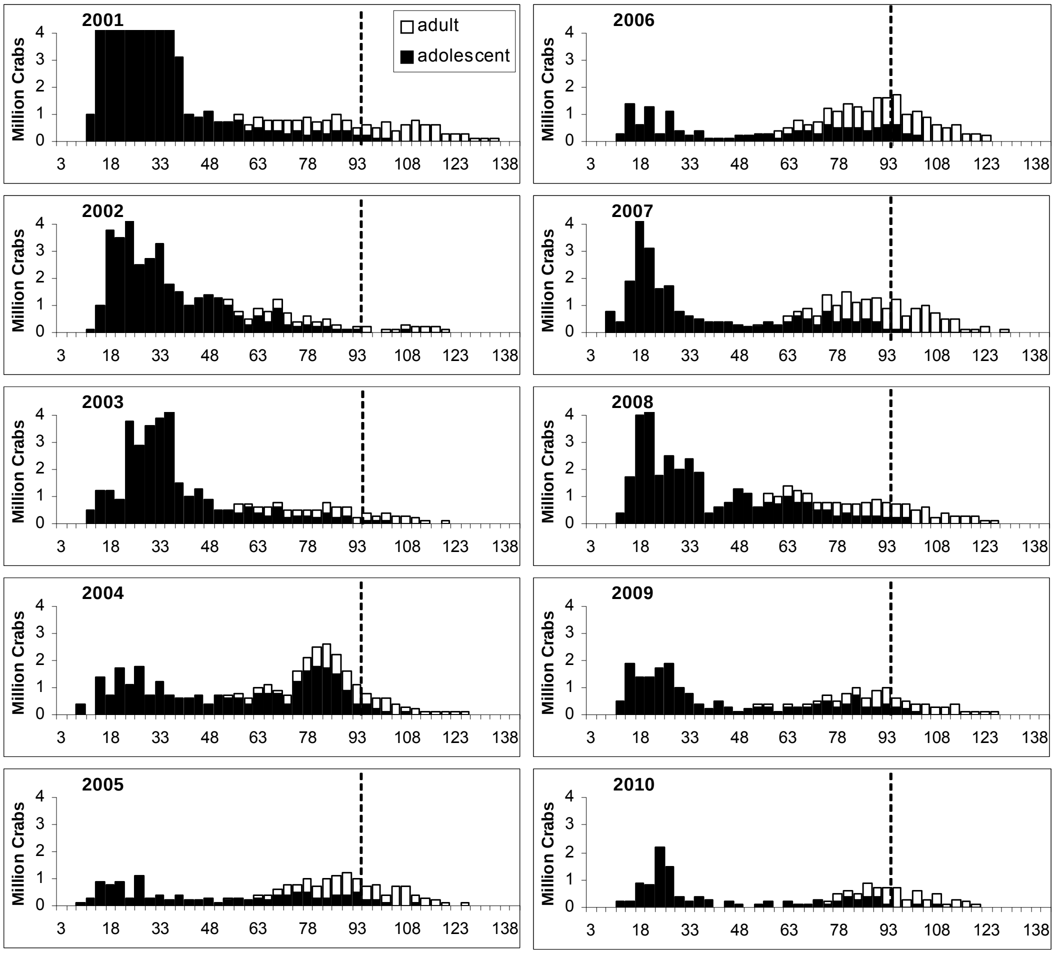


Figure 43: Abundance indices by carapace width for Div. 2J juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line.

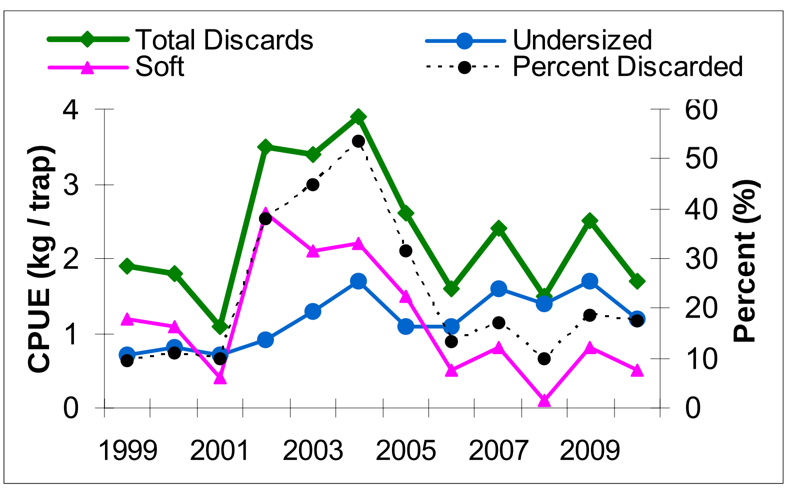


Figure 44: Trends in Division 2J observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

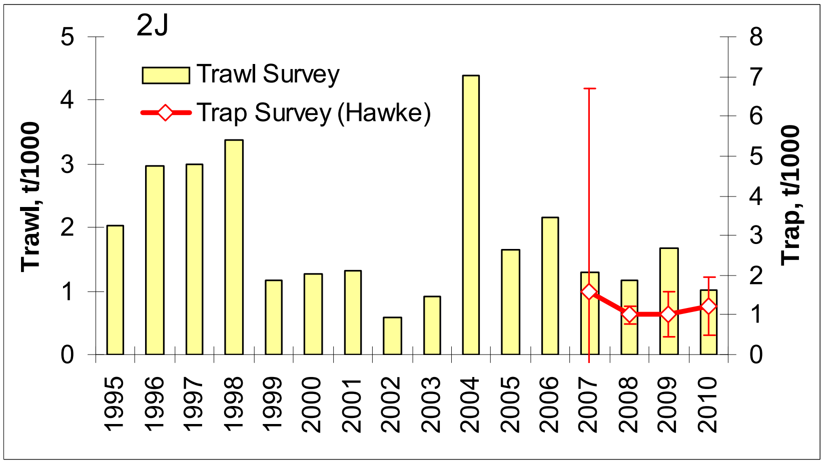


Figure 45: Trends in the Div. 2J fall trawl survey pre-recruit biomass index and the CPS trap survey biomass index.

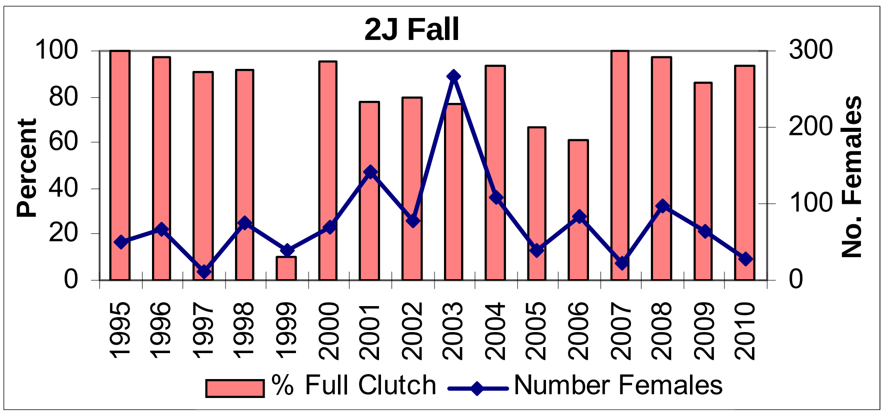


Figure 46: Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Div. 2J from fall multi-species surveys.

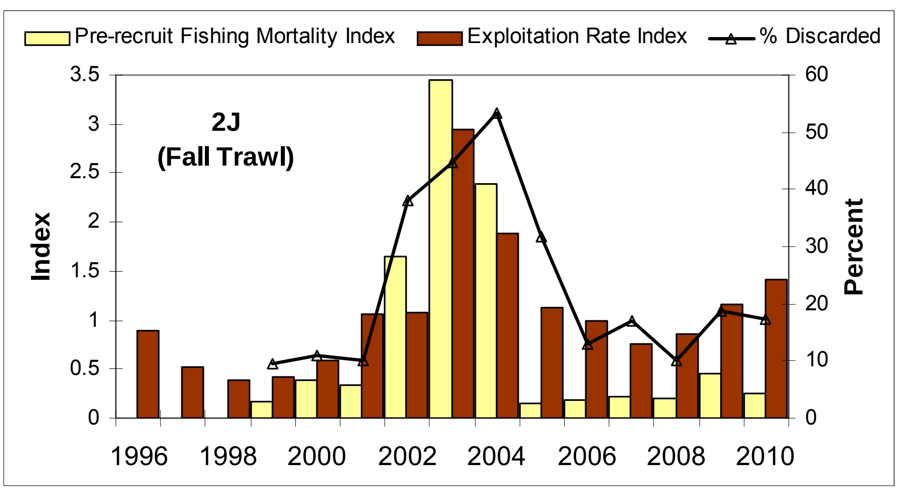


Figure 47: Trends in Div. 2J mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery.

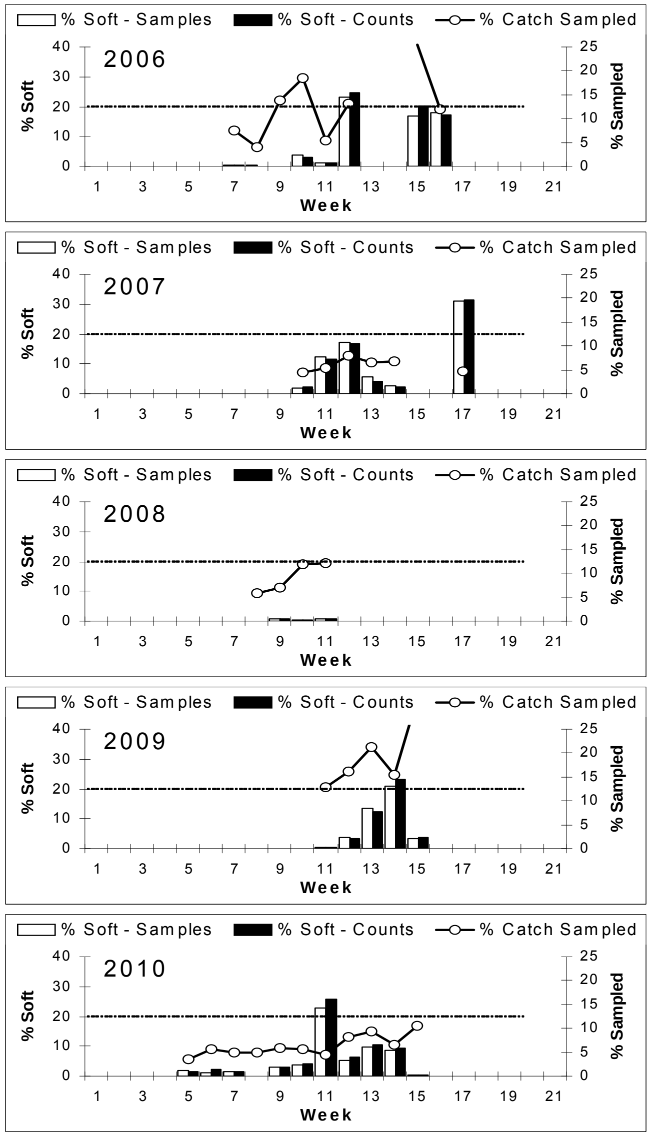


Figure 48: Trends in weekly percentages of soft-shell crab monitored and sampled in Div. 2J from 2006-2010.

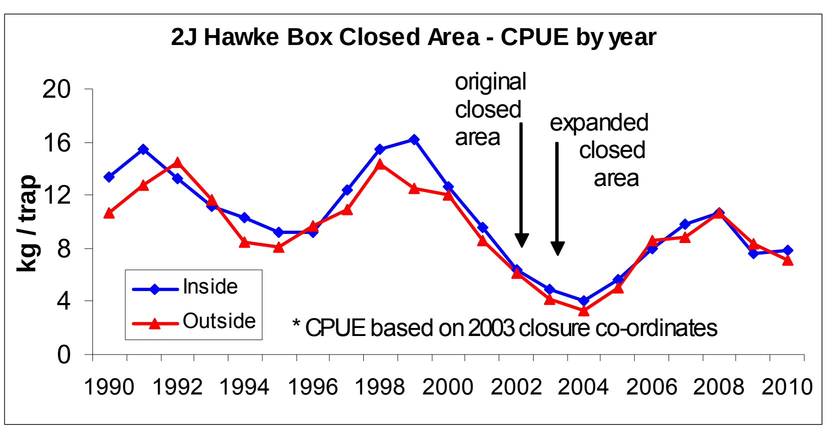


Figure 49: Div. 2J commercial CPUE; inside vs. outside the Hawke Channel closed area.

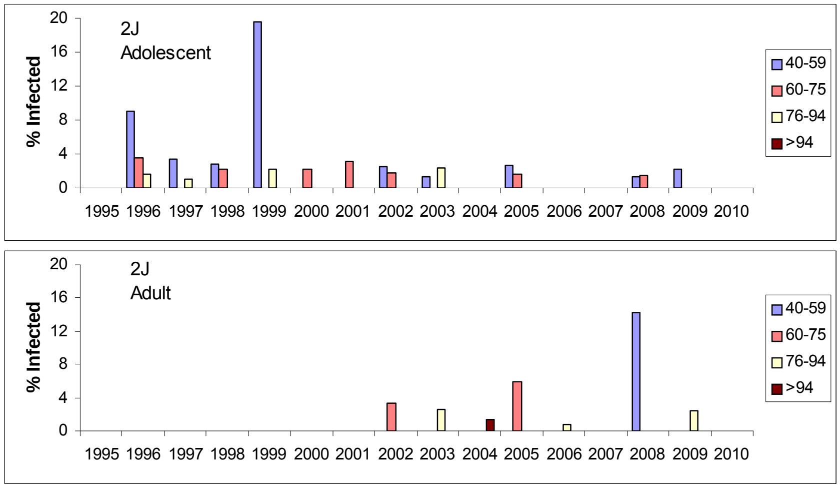


Figure 50: Trends in prevalence of BCD in new-shelled adolescents (above) and adults (below) by male size group from Div. 2J fall trawl surveys.

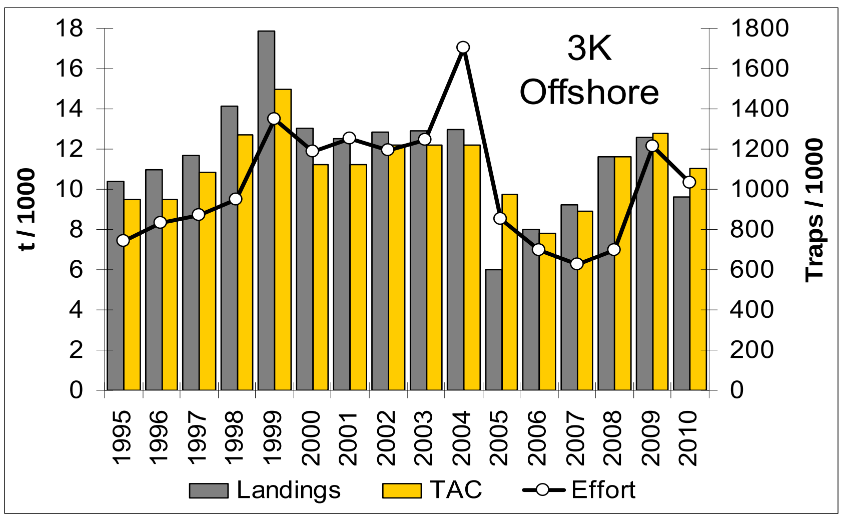


Figure 51: Trends in Div. 3K offshore landings, TAC, and fishing effort.

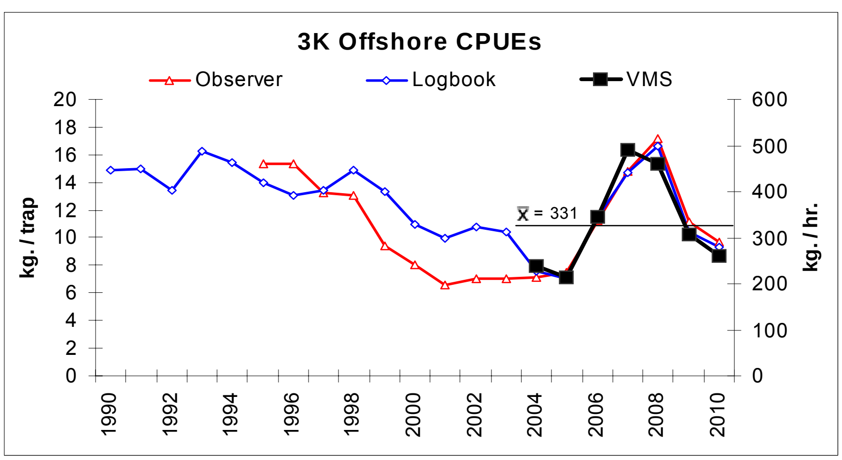


Figure 52: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Div. 3K offshore fishery. Solid black line denotes long-term VMS CPUE average.

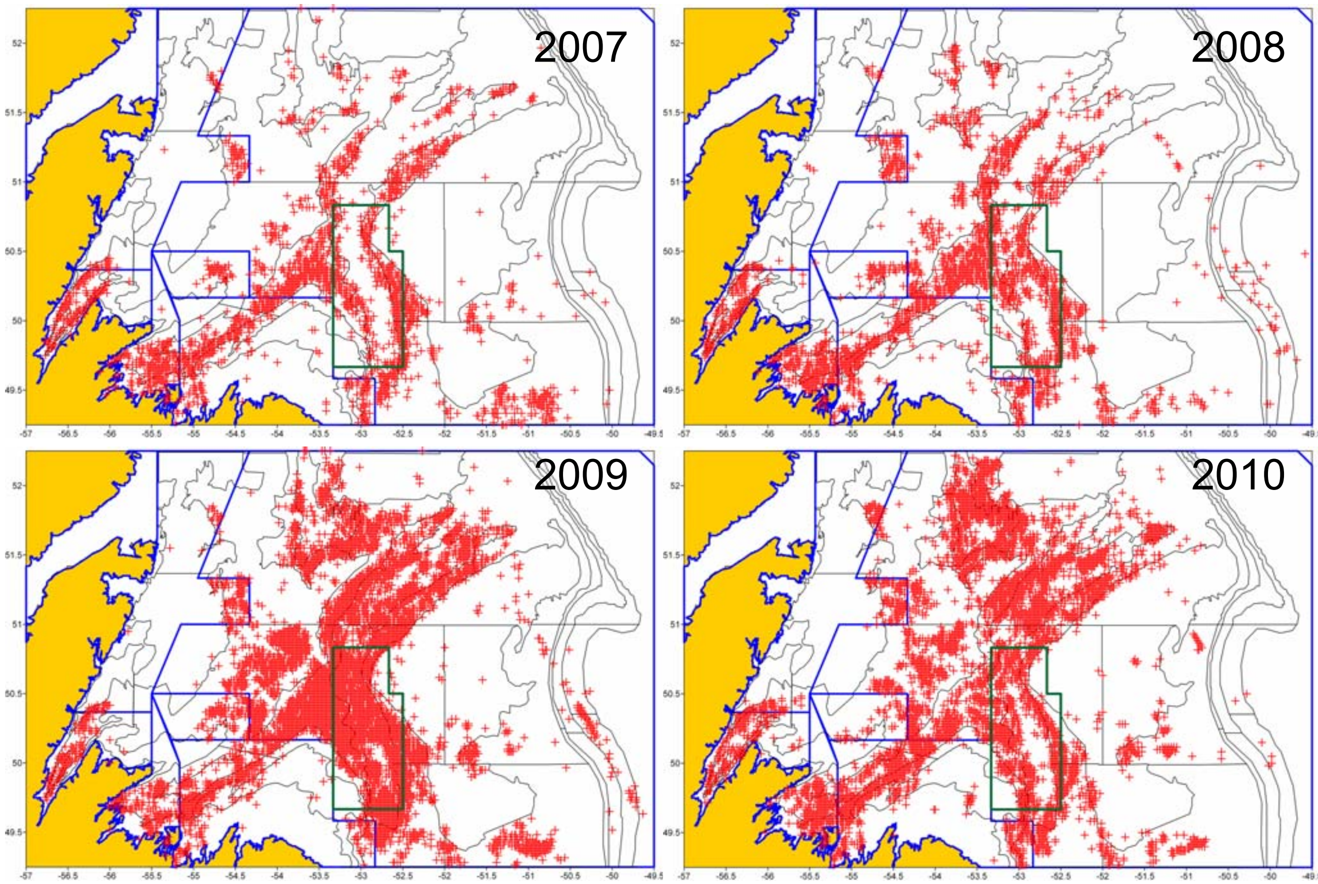


Figure 53: Spatial distribution of Div. 3K fishing effort by year.

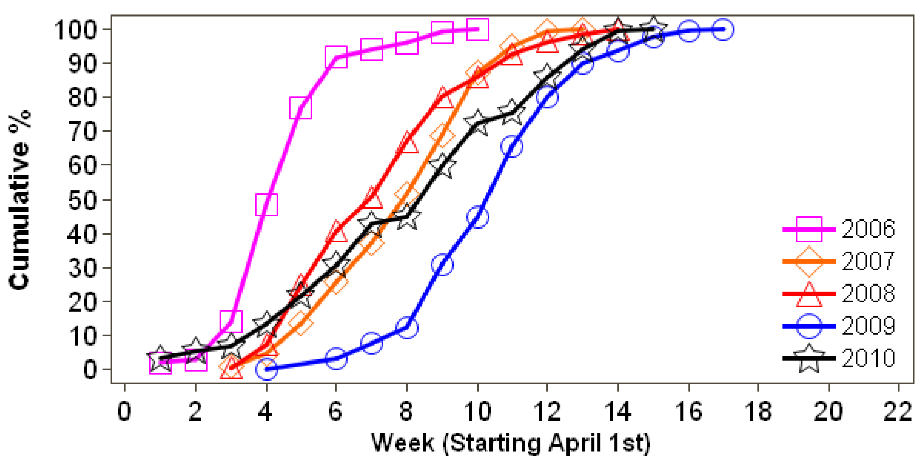


Figure 54: Seasonal trends in fishing effort for Div. 3K offshore during 2006-2010.

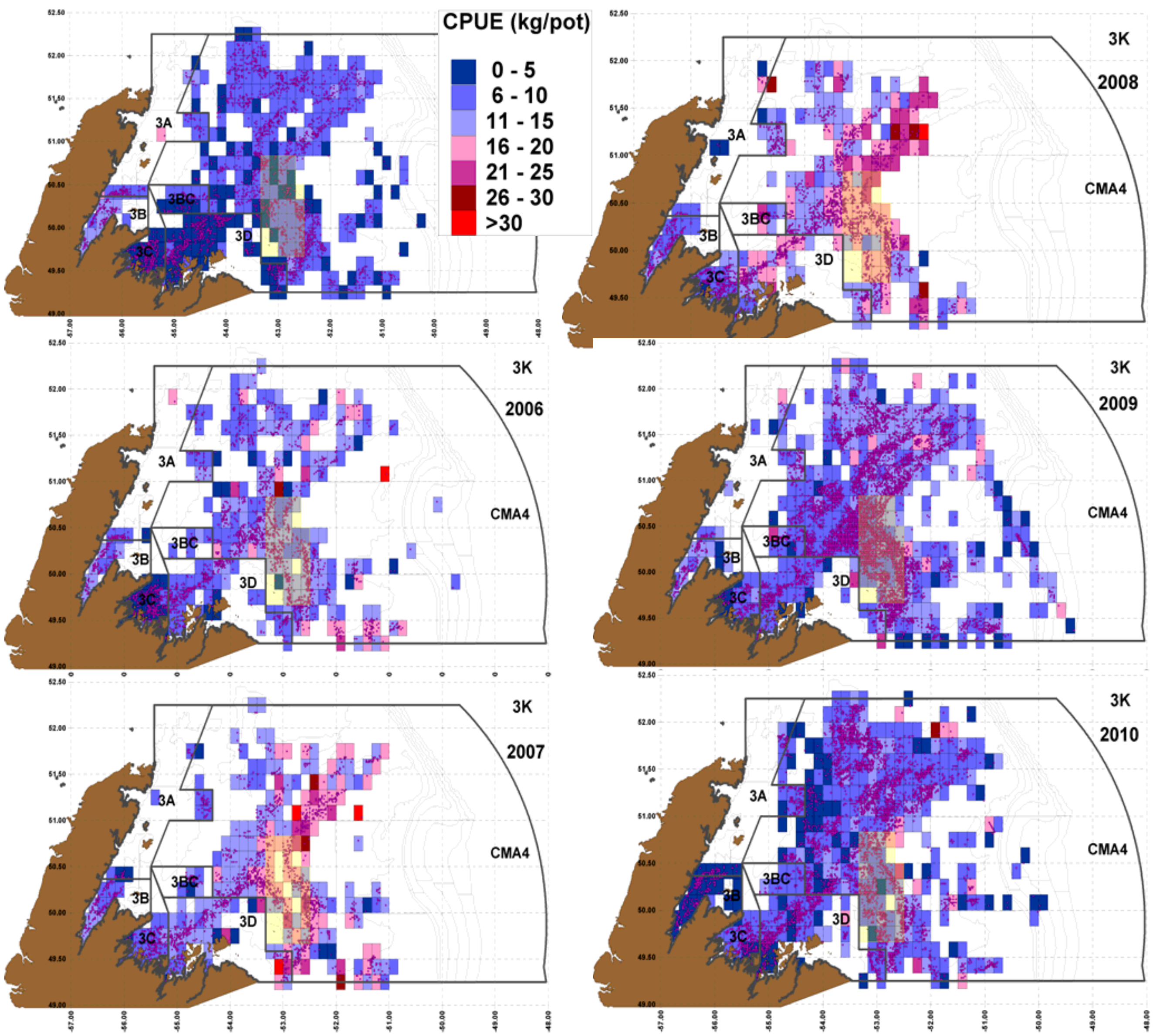


Figure 55: Spatial distribution of Div. 3K logbook CPUE by year.

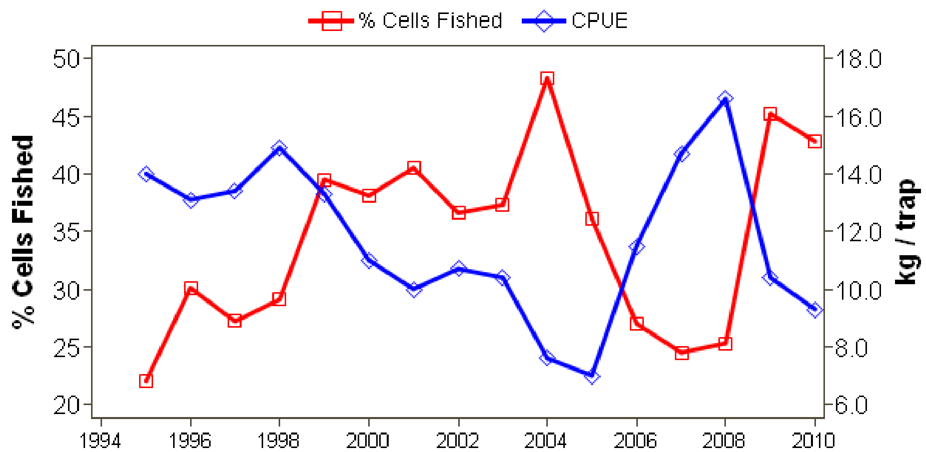


Figure 56: Trends in Div. 3K offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

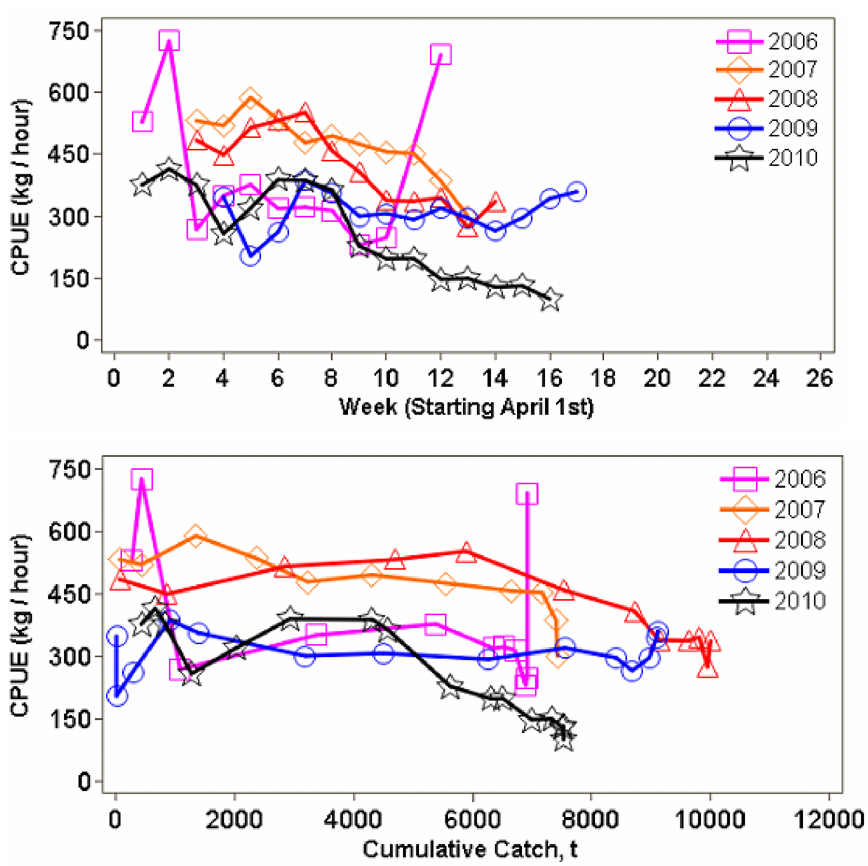


Figure 57: Seasonal trends in VMS-based CPUE for Div. 3K offshore during 2006-2010; (above) by week, and (below) in relation to cumulative catch.

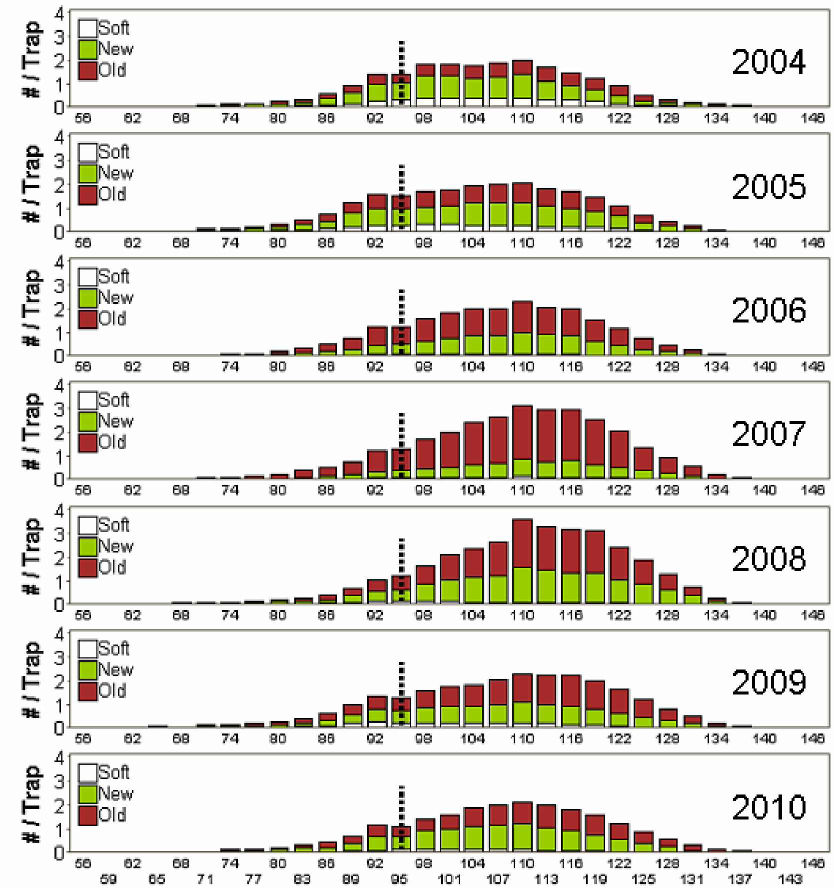


Figure 58: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Div. 3K offshore. The vertical dashed line indicates the minimum legal size.

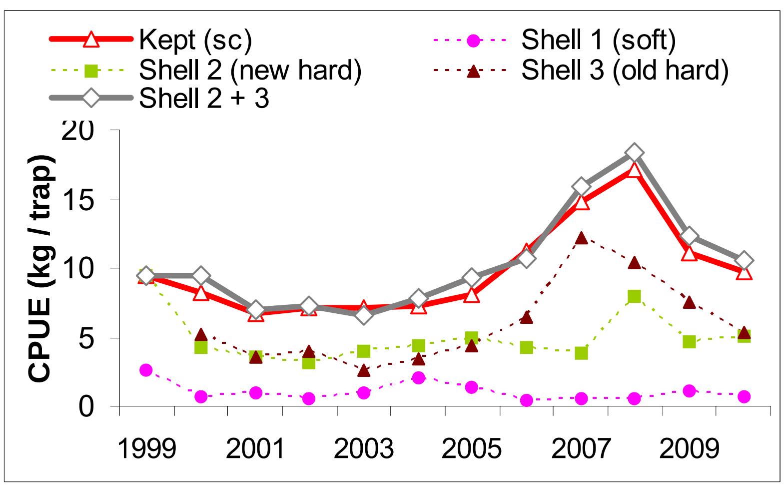


Figure 59: Trends in Division 3K offshore observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

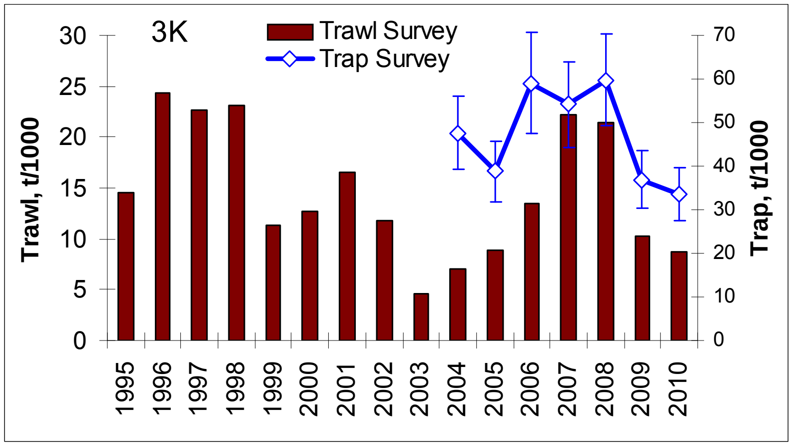


Figure 60: Trends in the Div. 3K offshore fall trawl survey exploitable biomass index and the CPS trap survey biomass index.

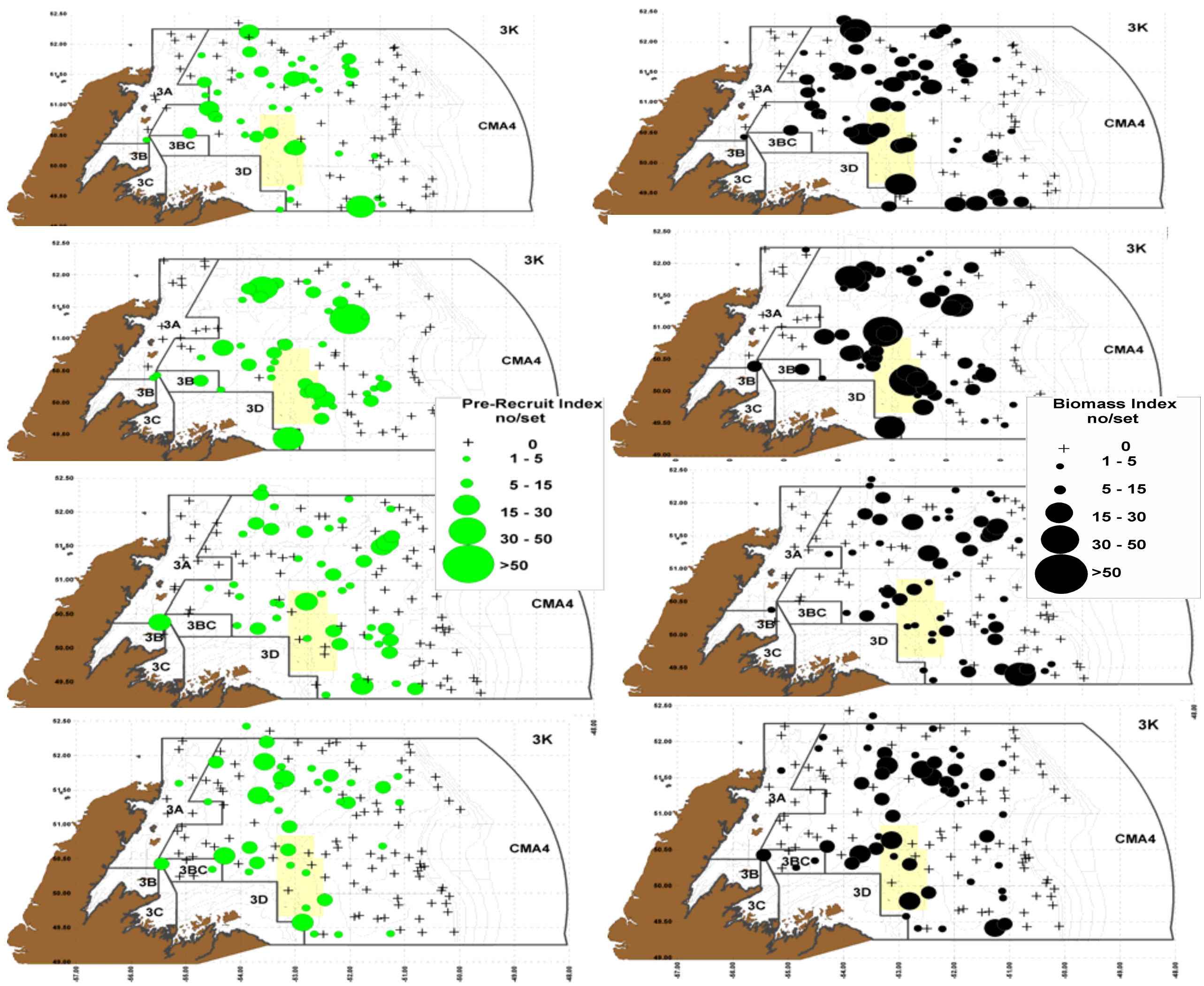


Figure 61. Spatial distribution of catches (number / set) or pre-recruit and exploitable snow crab in the Div. 3K offshore trawl survey.

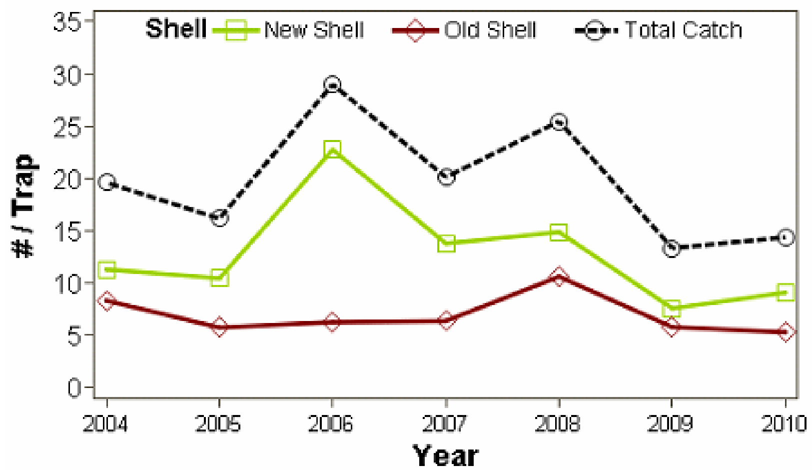


Figure 62: Trends in CPUE by shell condition for legal-sized crabs from core stations in the Div. 3K offshore CPS trap survey.

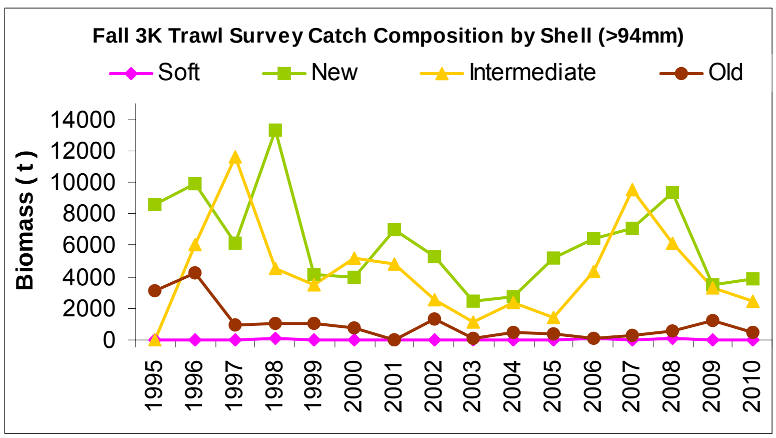


Figure 63: Trends, by shell condition, in biomass of legal-sized males for Div. 3K offshore from fall trawl surveys.

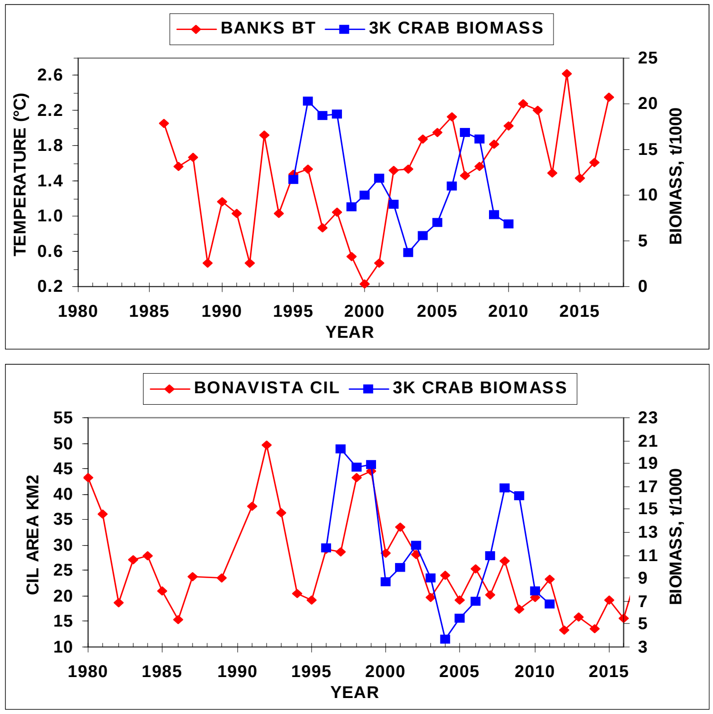


Figure 64: Trends in the Div. 3K offshore exploitable biomass index vs. bottom temperature at a seven year lag (above) and vs. the spatial extent of the cold intermediate layer at a seven year lag (below).

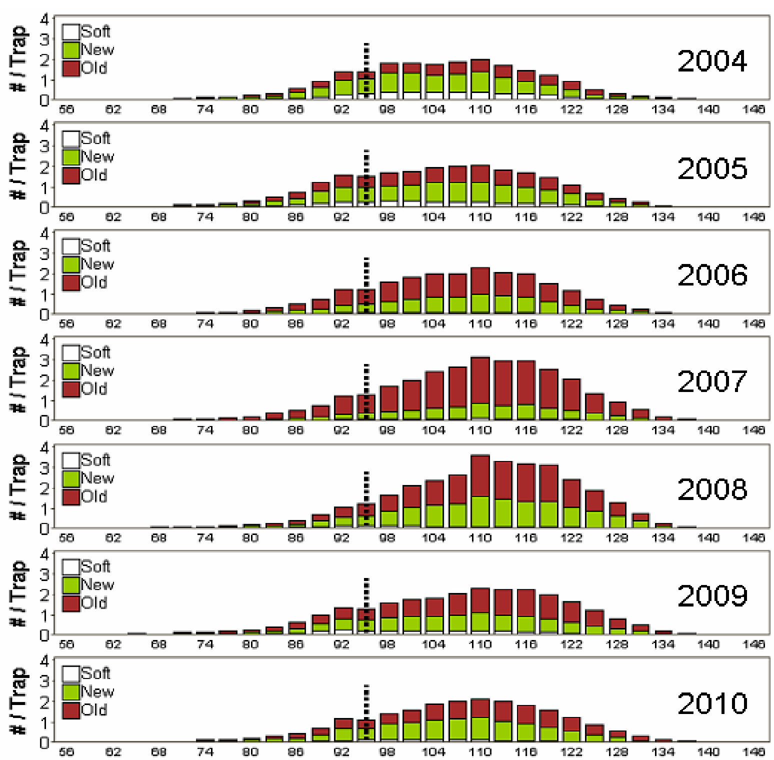


Figure 65: Trends in male carapace width distributions from core stations in the Div. 3K offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

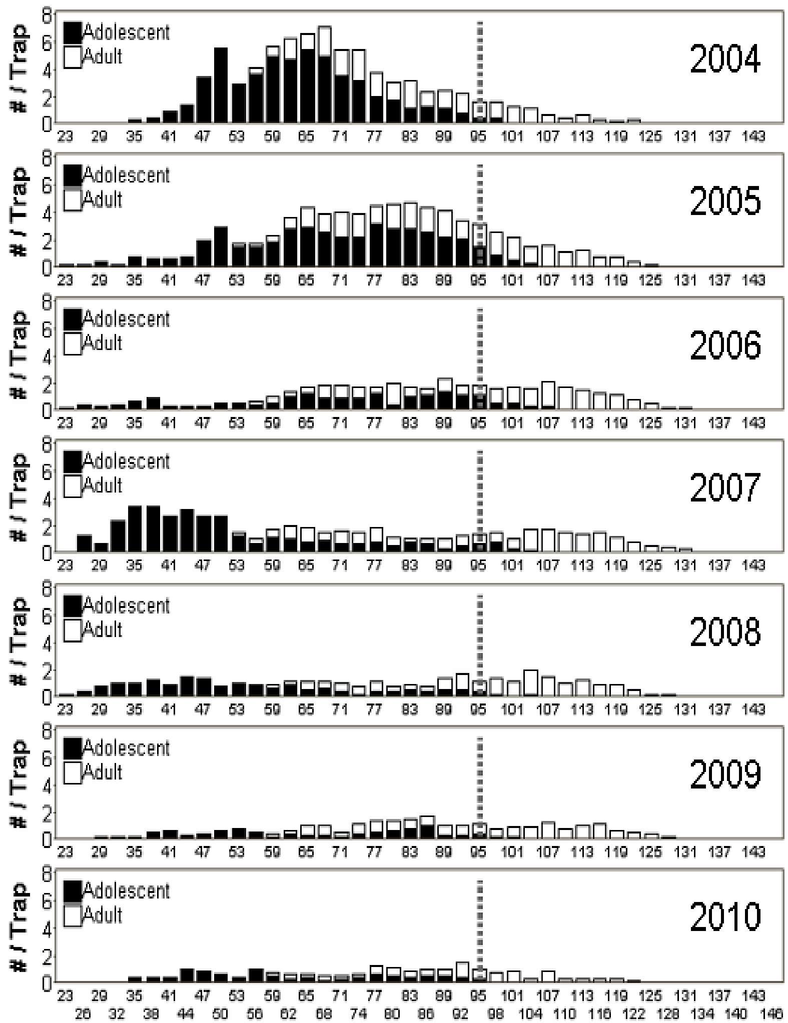


Figure 66: Trends in male carapace width distributions from small-mesh traps in the Div. 3K offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

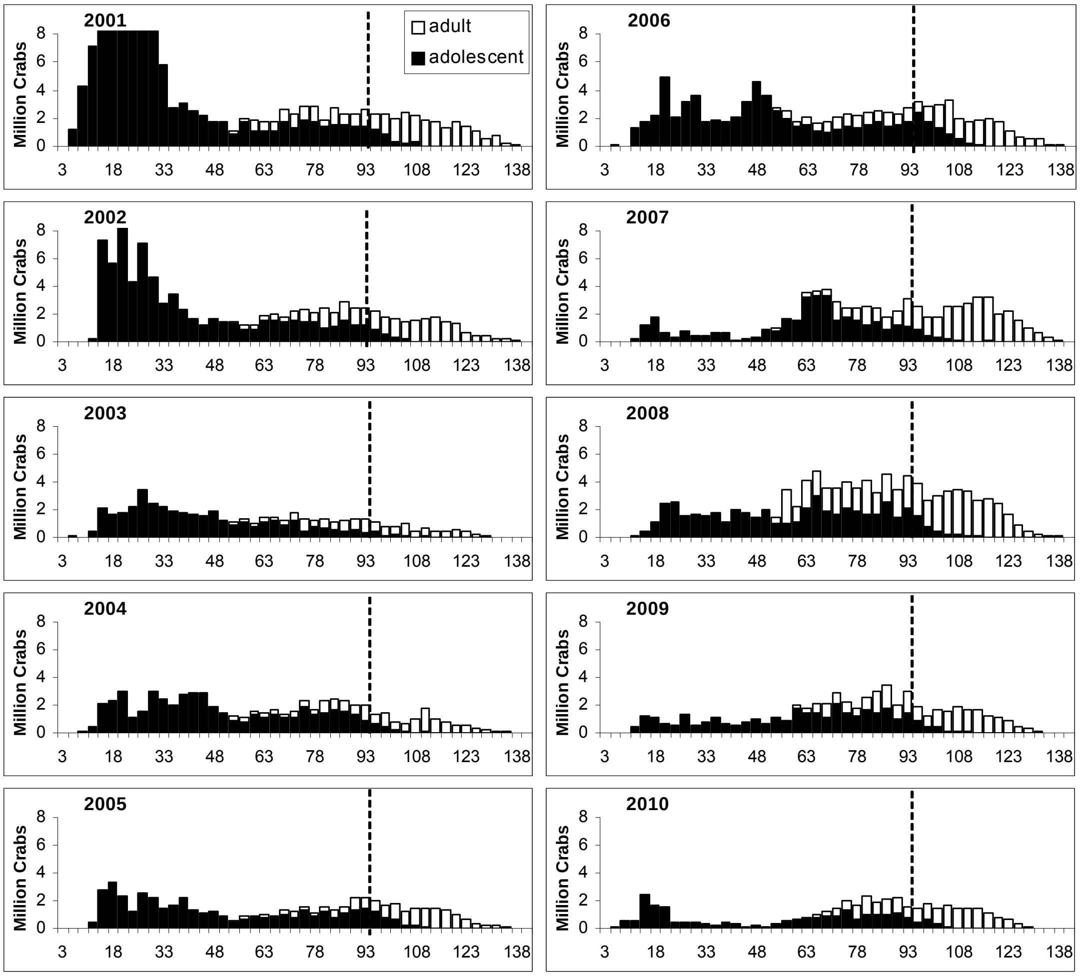


Figure 67: Abundance indices by carapace width for Div. 3K juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line.

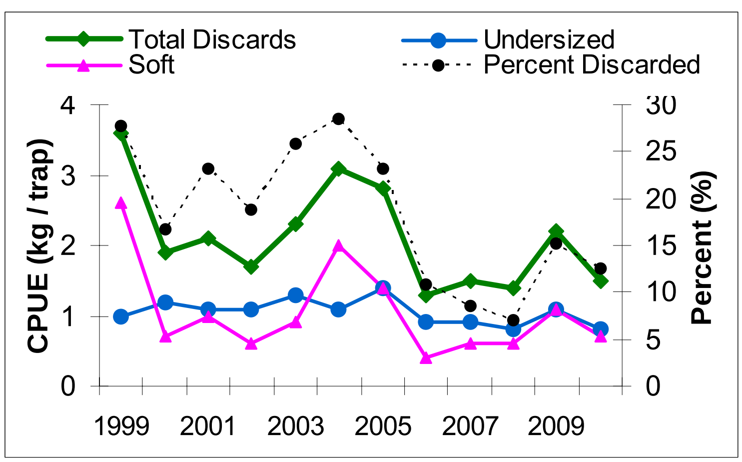


Figure 68: Trends in Division 3K offshore observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

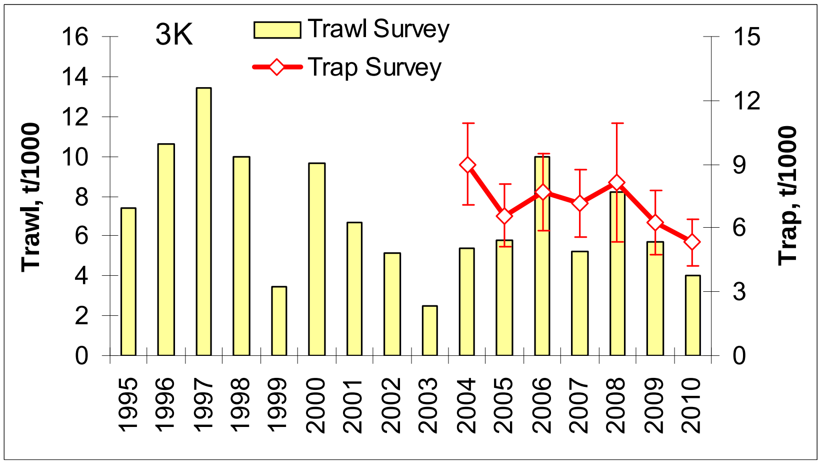


Figure 69: Trends in the Div. 3K fall trawl survey pre-recruit biomass index and the CPS trap survey biomass index.

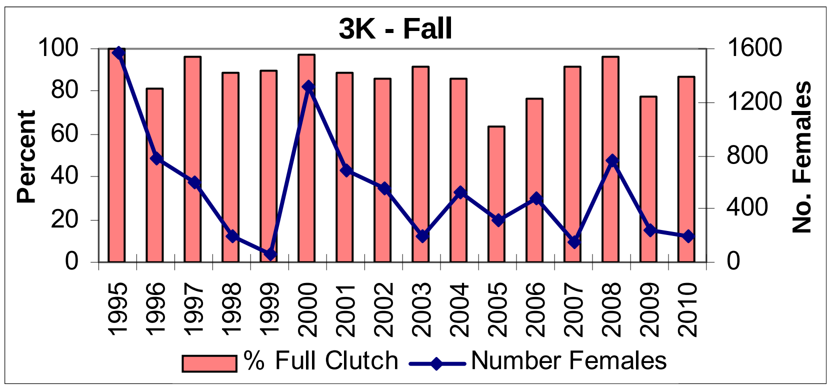


Figure 70: Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Div. 3K from fall multi-species surveys.

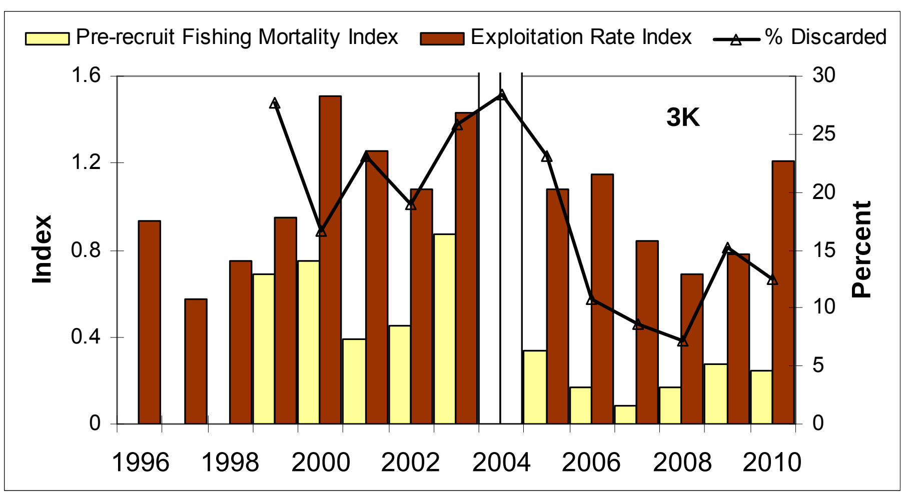


Figure 71: Trends in Div. 3K offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery (anomalously high 2004 values are attributable to low catch rates in 2003 trawl survey).

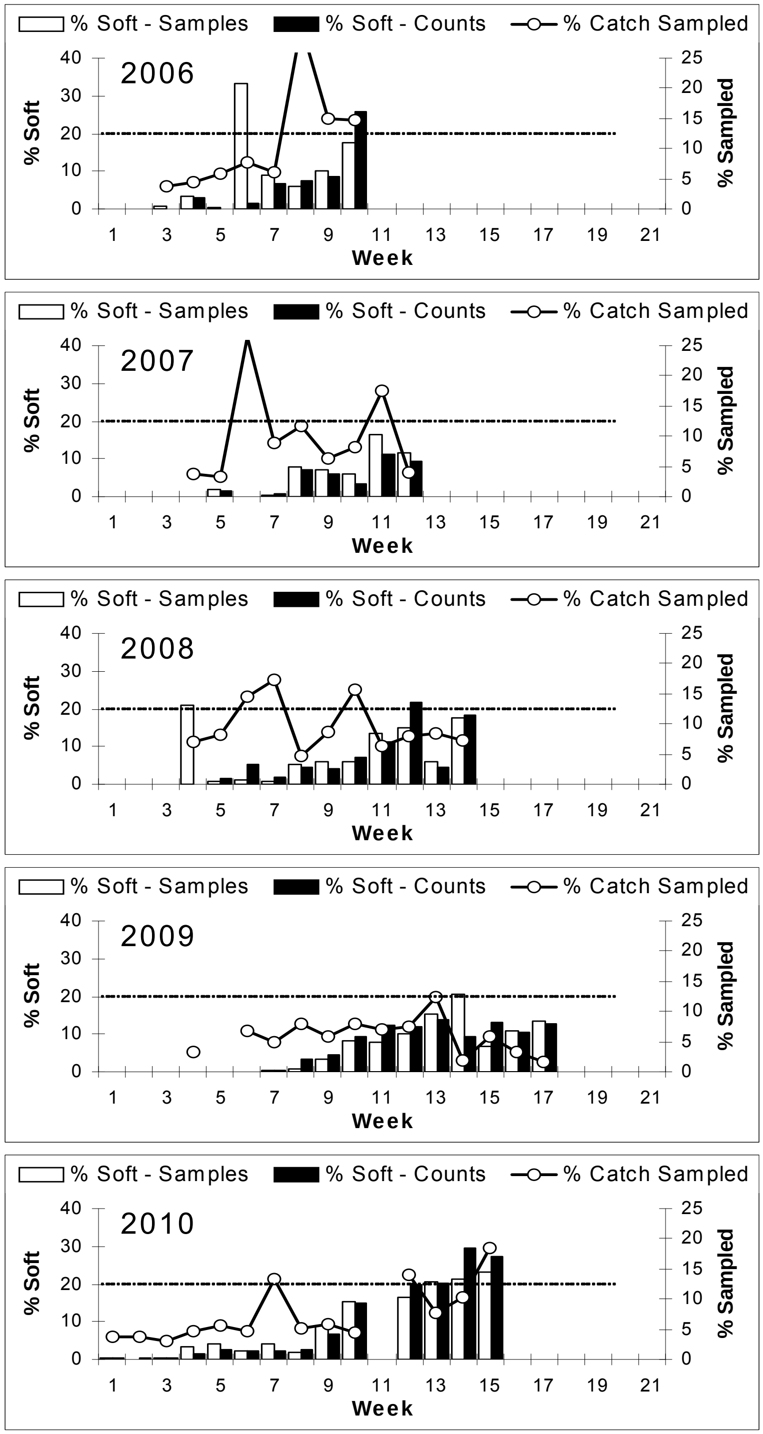


Figure 72: Trends in weekly percentages of soft-shell crab monitored and sampled in Div. 3K Offshore from 2006-2010.

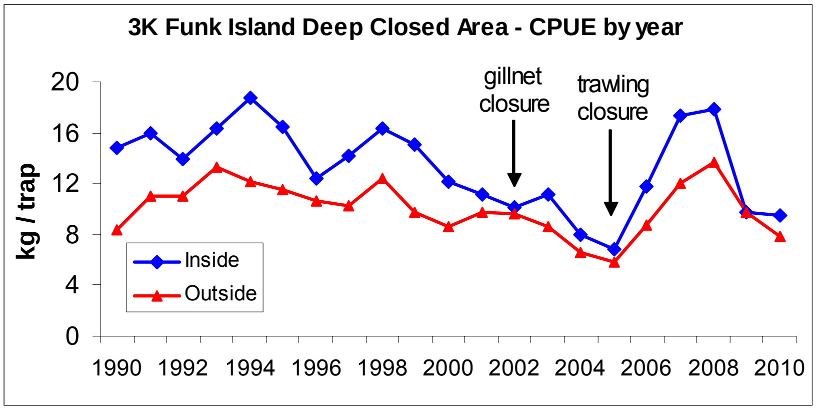


Figure 73: Div. 3K offshore commercial CPUE; inside vs. outside the Funk Island Deep closed area.

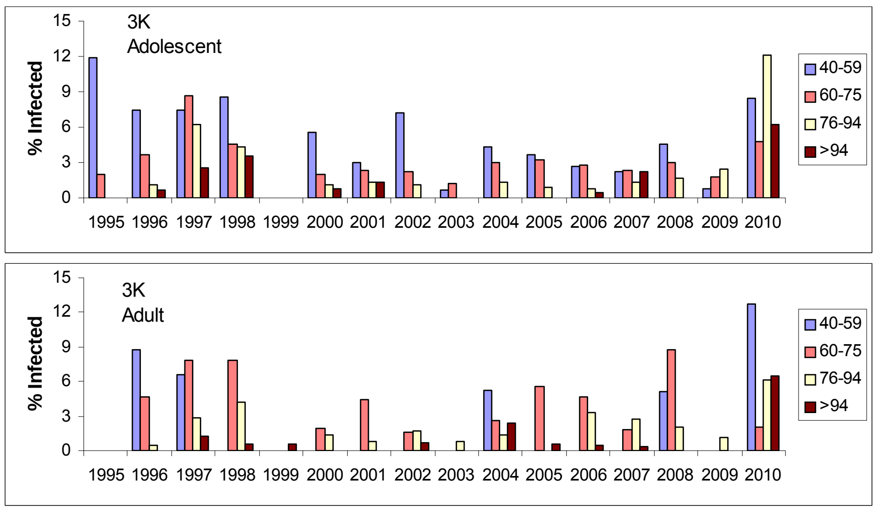


Figure 74: Trends in prevalence of BCD in new-shelled adolescents (above) and adults (below) by male size group from Div. 3K fall trawl surveys.

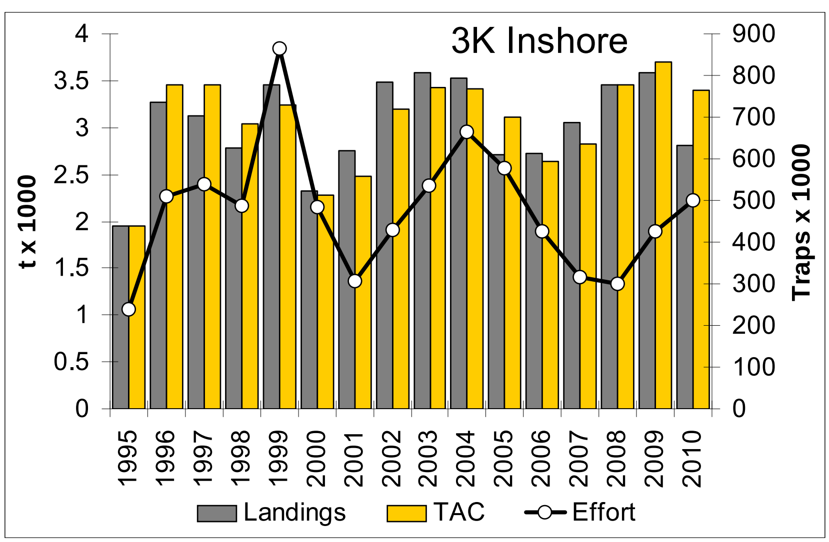


Figure 75: Trends in Div. 3K inshore landings, TAC, and fishing effort.

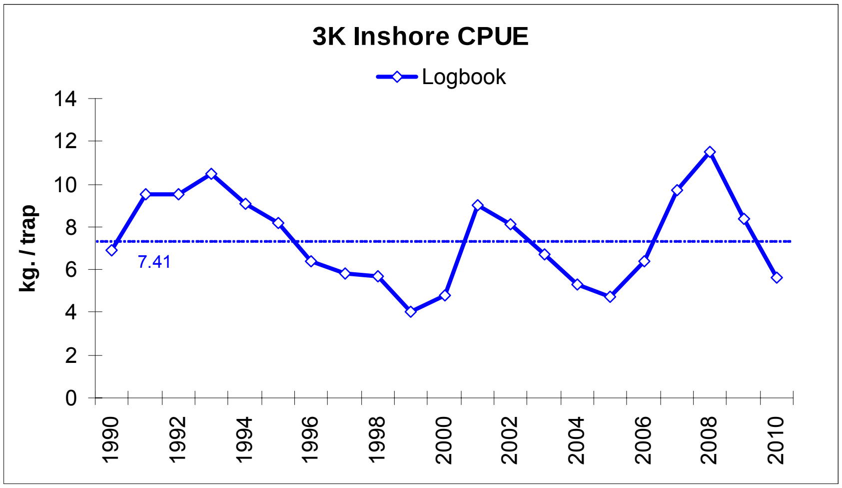


Figure 76: Trends in commercial logbook-based CPUE in the Div. 3K inshore fishery. Dashed line denotes the long-term average.

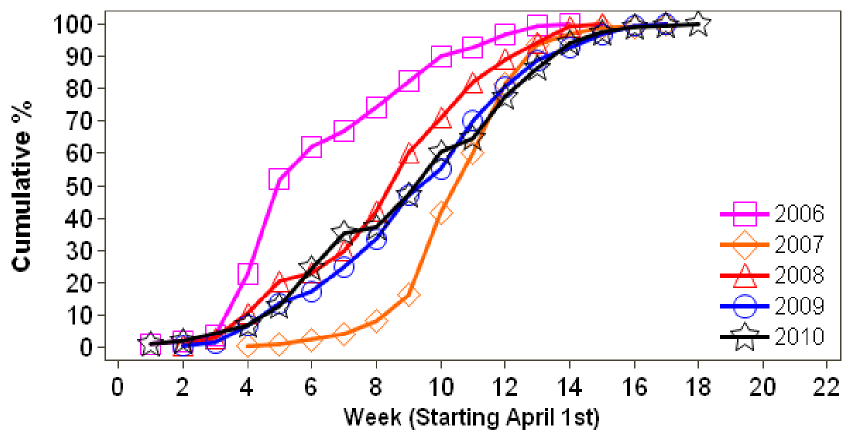


Figure 77: Seasonal trends in weekly fishing effort for Div. 3K inshore during 2006-2010.

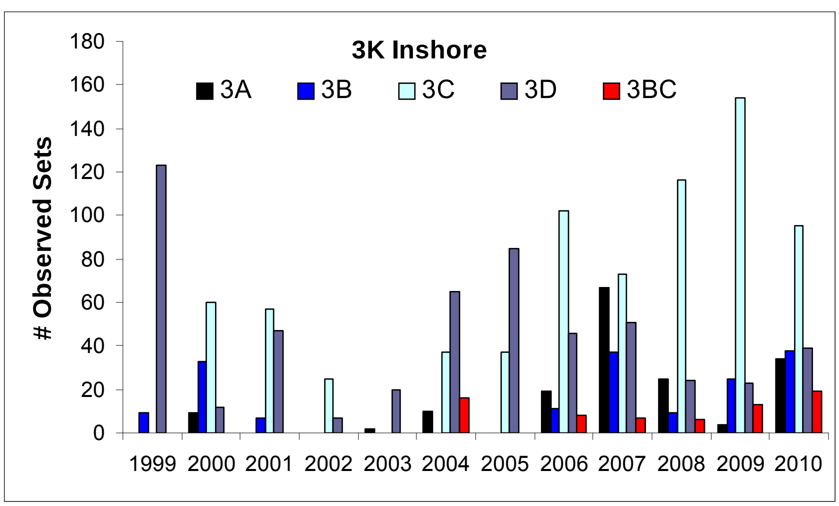


Figure 78: Trends in number of observed sets by Crab Management Areas and year in Division 3K inshore.

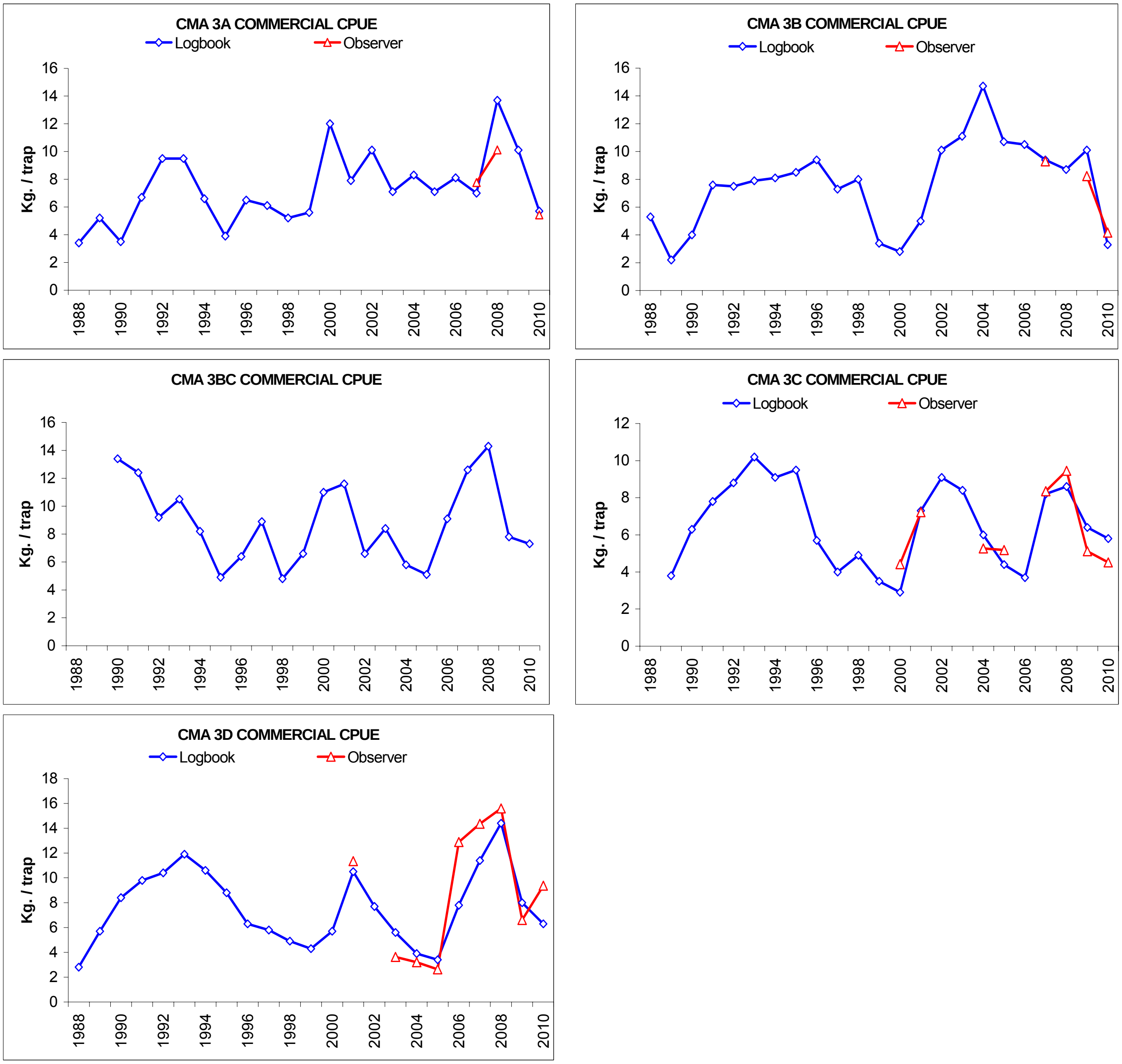


Figure 79: Trends in Division 3K inshore logbook CPUE and observer CPUE by Crab Management Area.

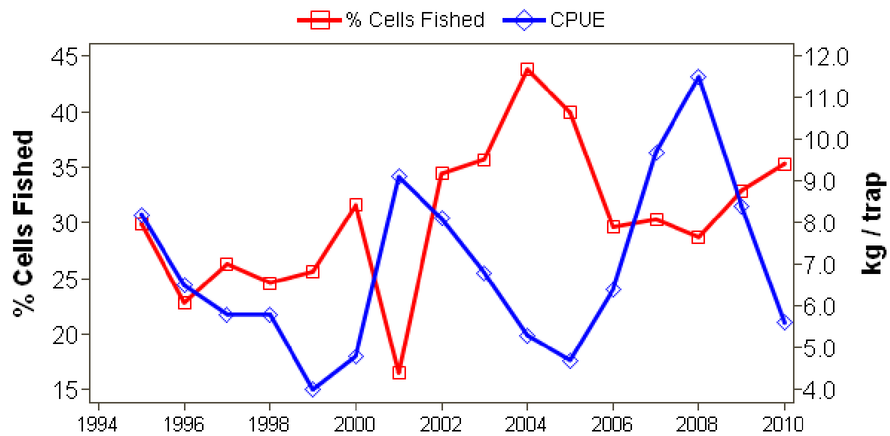


Figure 80: Trends in Div. 3K inshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

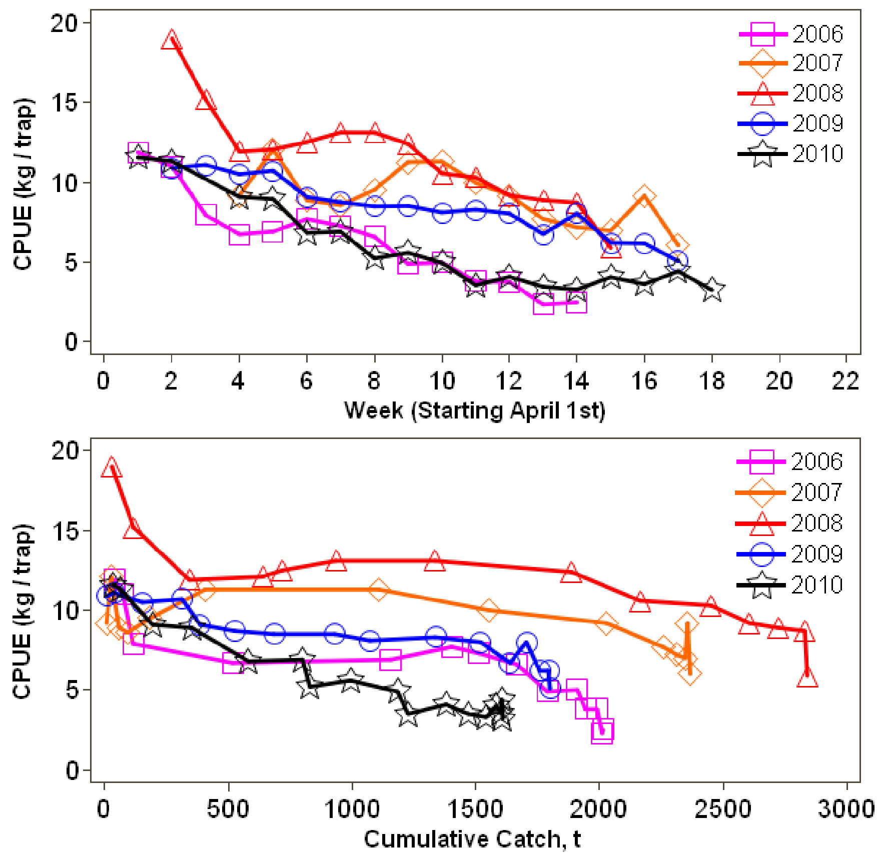


Figure 81: Seasonal trends in logbook-based CPUE for Div. 3K inshore during 2006-2010; (above) by week, and (below) in relation to cumulative catch.

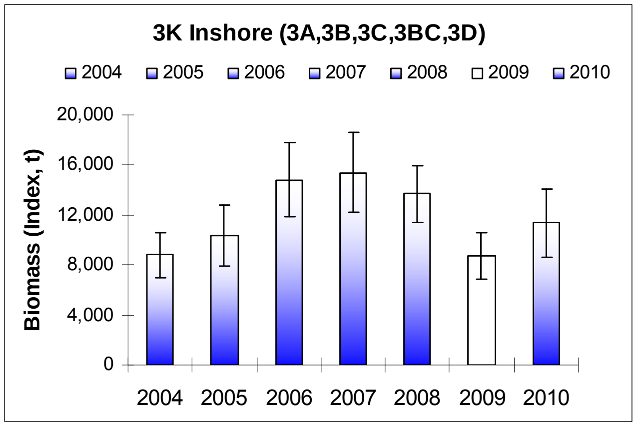


Figure 82: Exploitable biomass index based on the CPS trap survey in Div. 3K inshore.

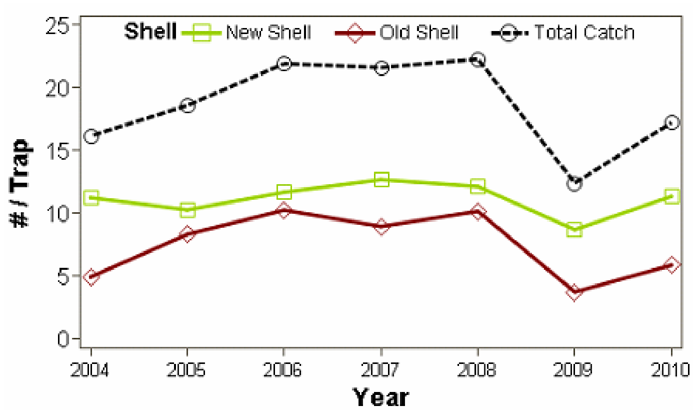


Figure 83: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Div. 3K inshore.

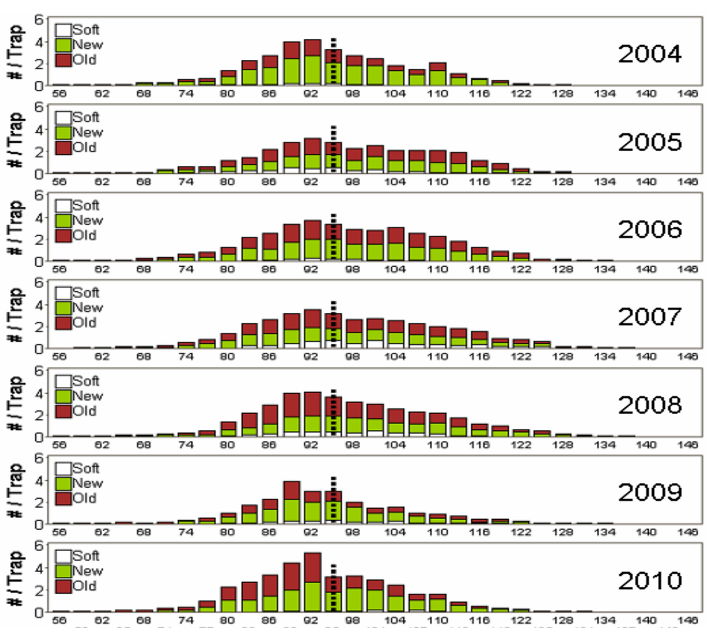


Figure 84: Trends in male carapace width distributions from core stations in the Div. 3K inshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

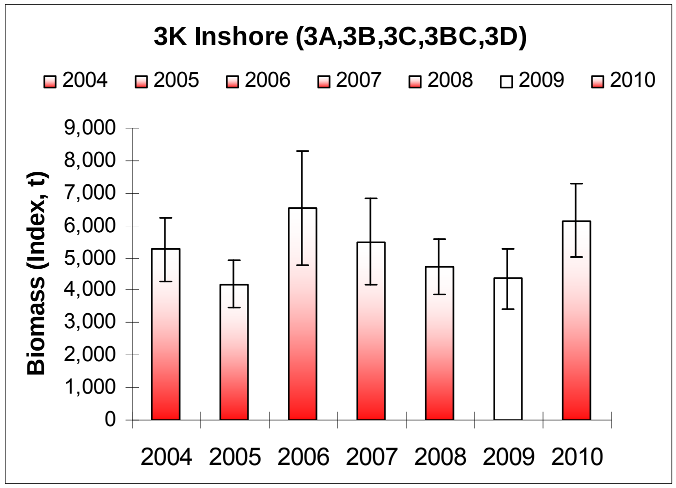


Figure 85: Pre-recruit biomass index based on the CPS trap survey in Div. 3K inshore.

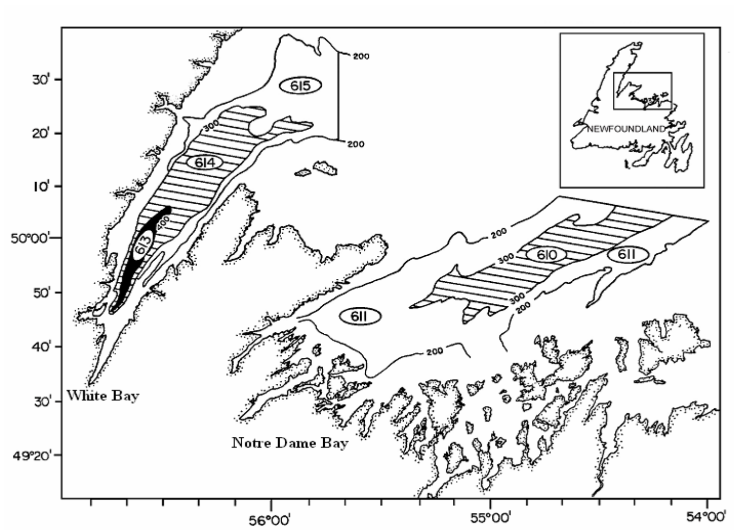


Figure 86: Location map showing inshore Div. 3K strata sampled during fall trap surveys in White Bay and Notre Dame Bay.

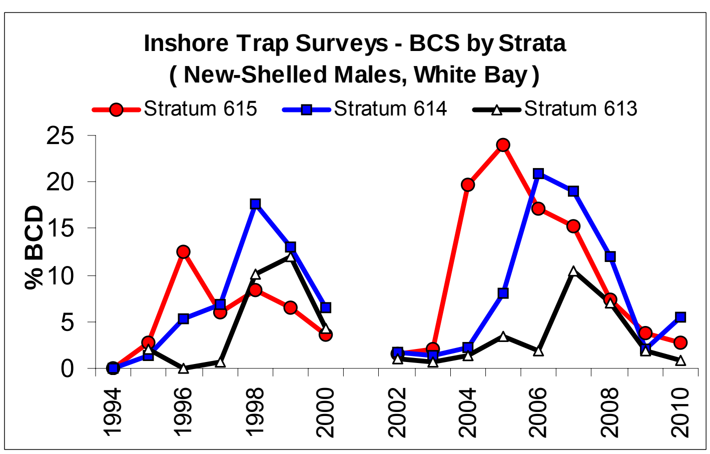


Figure 87: Prevalence of BCD in new-shelled males from Div. 3K DFO inshore trap surveys by stratum in White Bay.

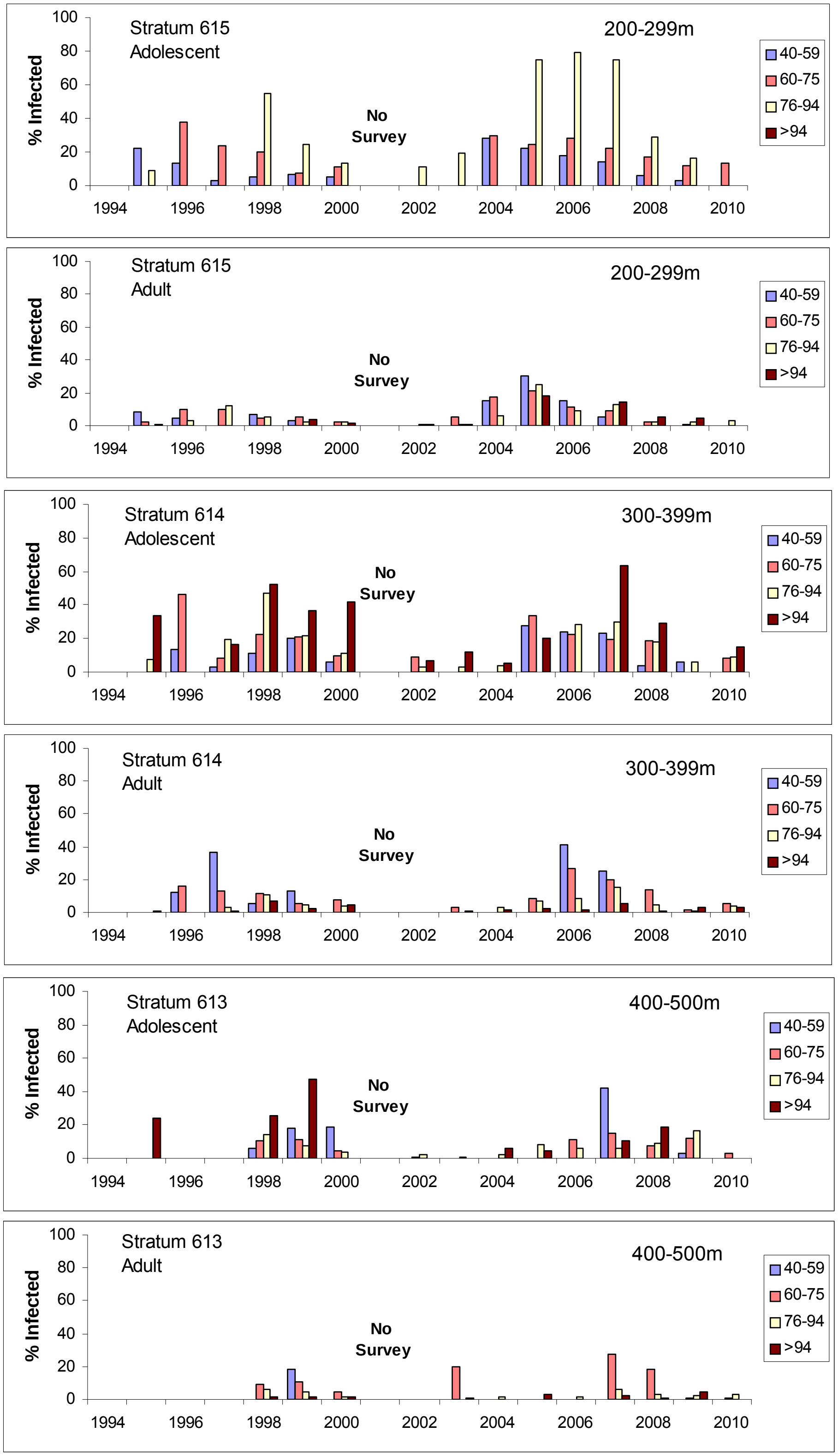


Figure 88: Trends of prevalence of BCD in new-shelled males by stratum, year and size group from DFO trap surveys in White Bay; adolescents (above) and adults (below).

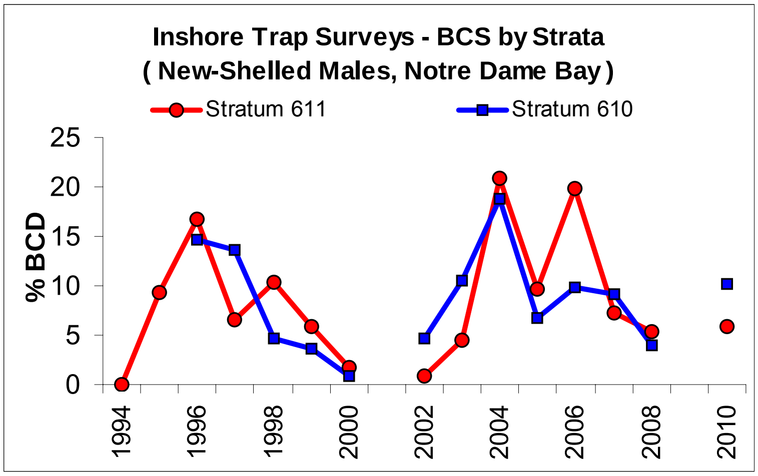


Figure 89: Prevalence of BCD in new-shelled males from Div. 3K DFO inshore trap surveys by stratum in Notre Dame Bay.

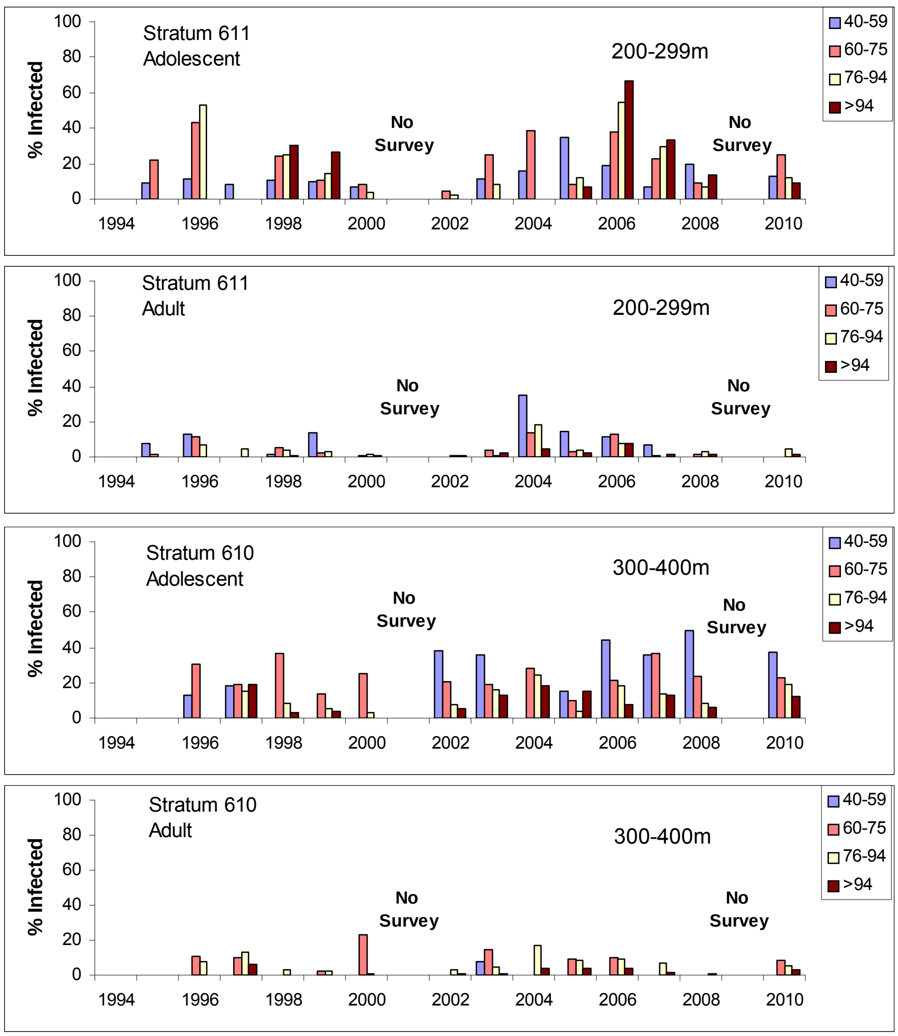


Figure 90: Trends of prevalence of BCD in new-shelled males by stratum, year and size group from DFO trap surveys in White Bay; adolescents (above) and adults (below).

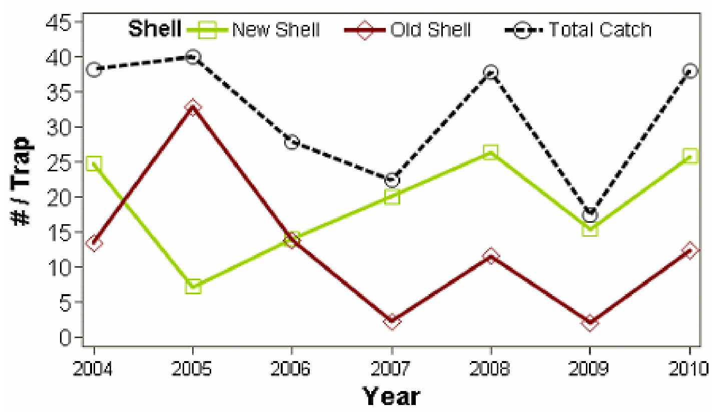


Figure 91: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 3B.

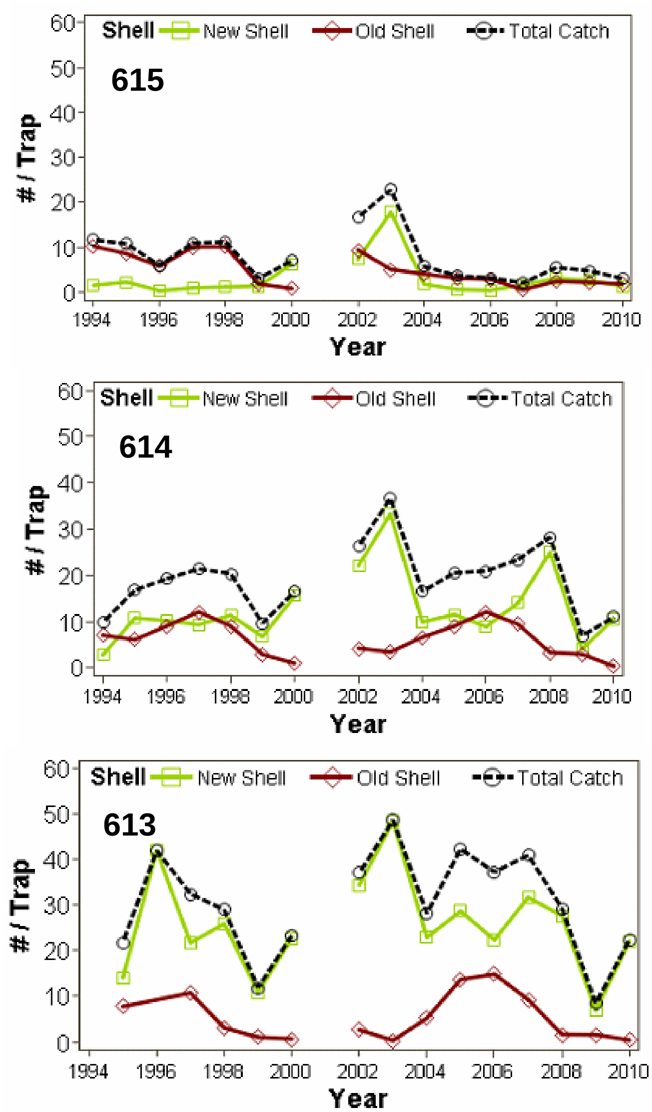


Figure 92: Trends in CPUE by shell condition for legal-sized crabs from strata occupied in the DFO trap survey in White Bay. No survey was conducted in 2001.

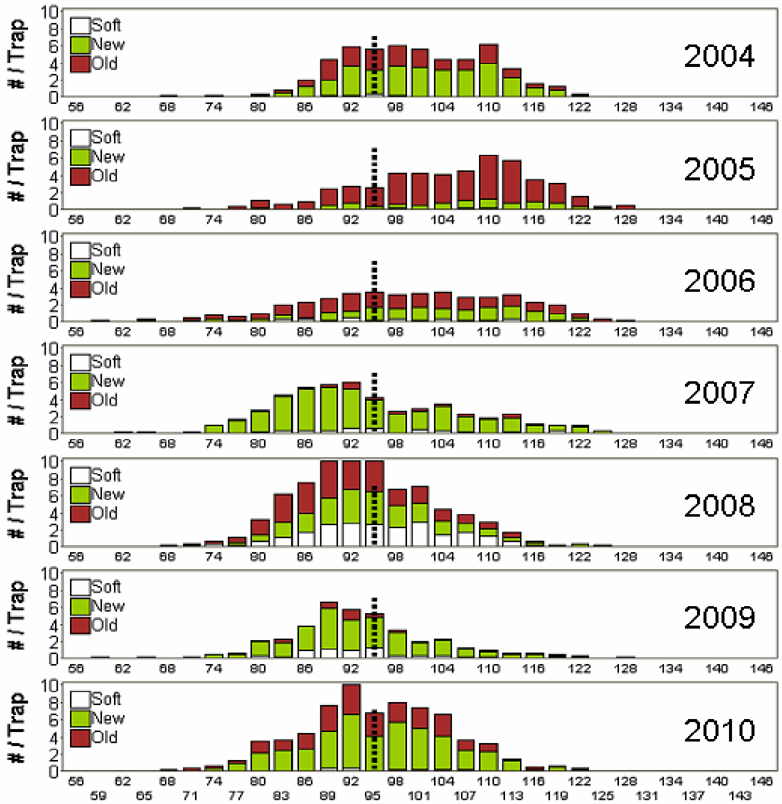


Figure 93: Trends in male carapace width distributions from core stations in CMA 3B from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

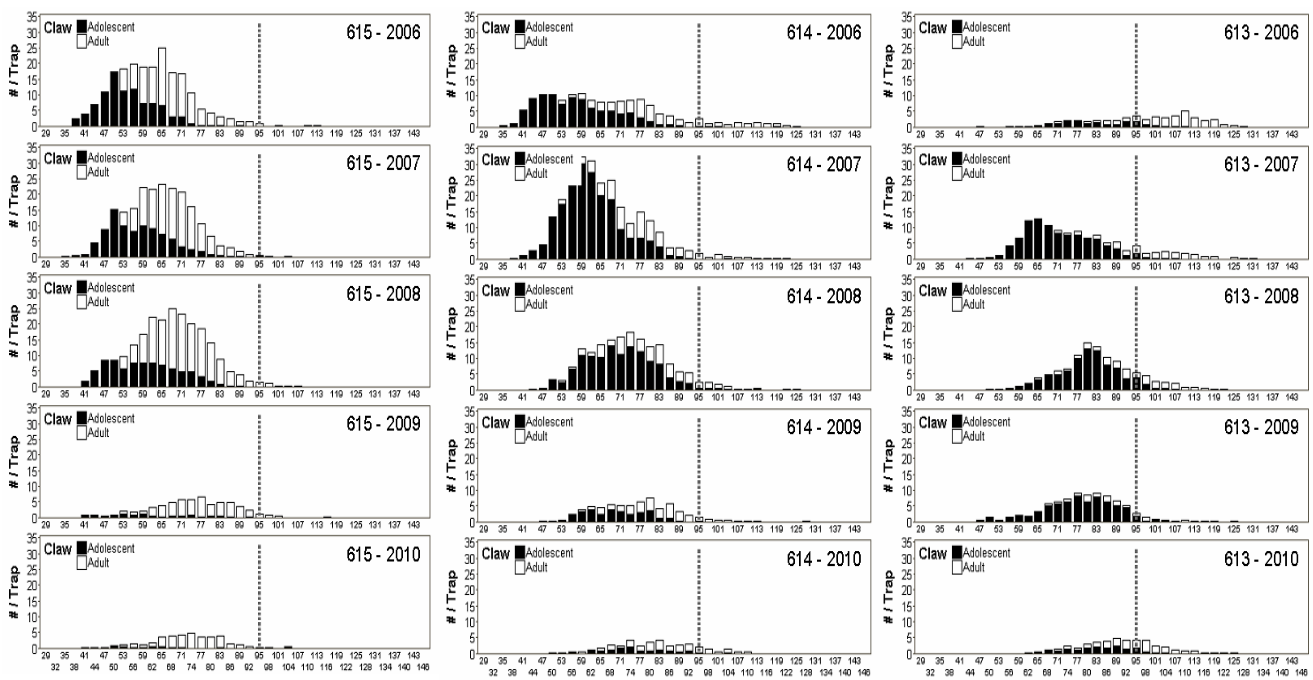


Figure 94: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in DFO trap survey in White Bay from 2006-2010. The vertical dashed line indicates the minimum legal size.

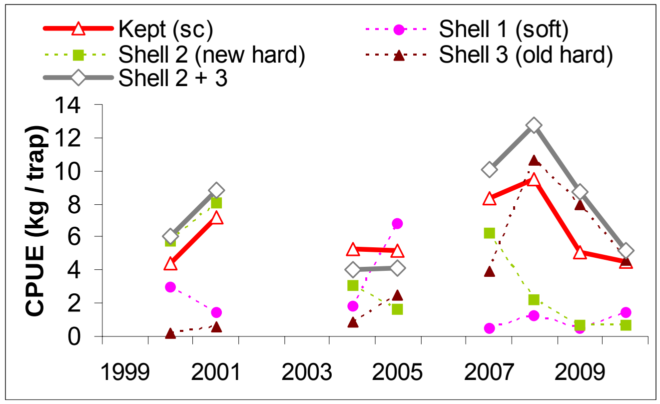


Figure 95: Trends in CMA 3C observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

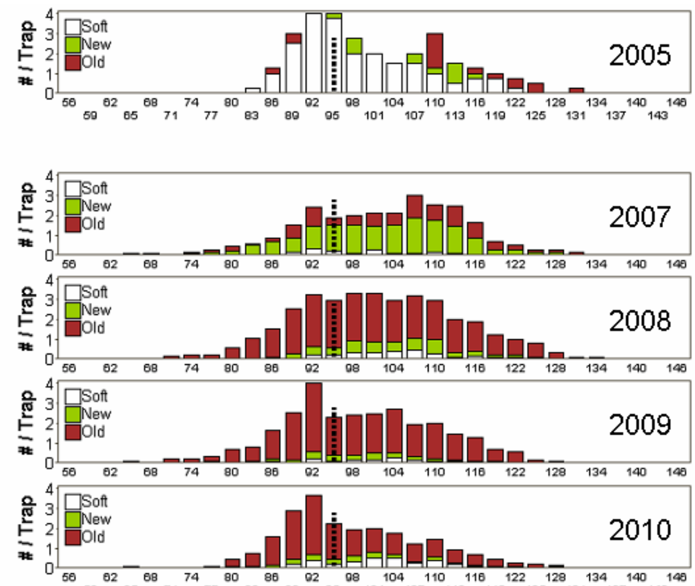


Figure 96: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 3C. The vertical dashed line indicates the minimum legal size.

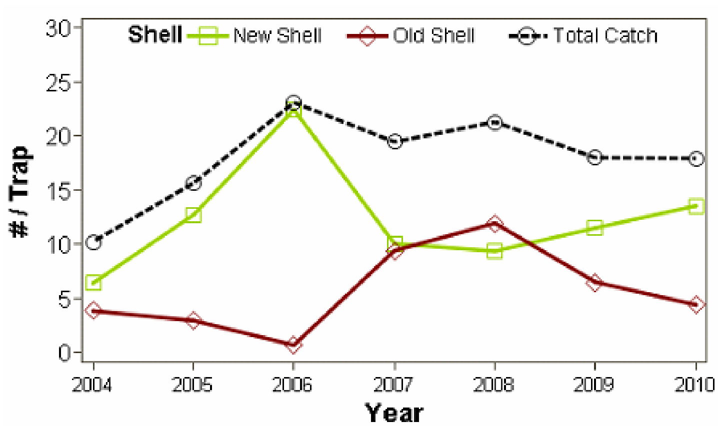


Figure 97: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 3C.

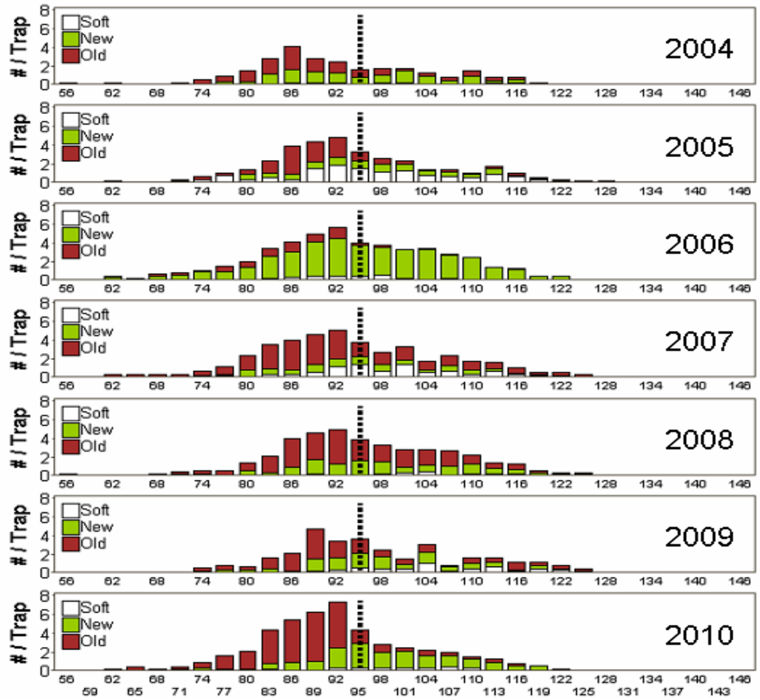


Figure 98: Trends in male carapace width distributions from core stations in CMA 3C from the CPS survey. The vertical dashed line indicates the minimum legal size.

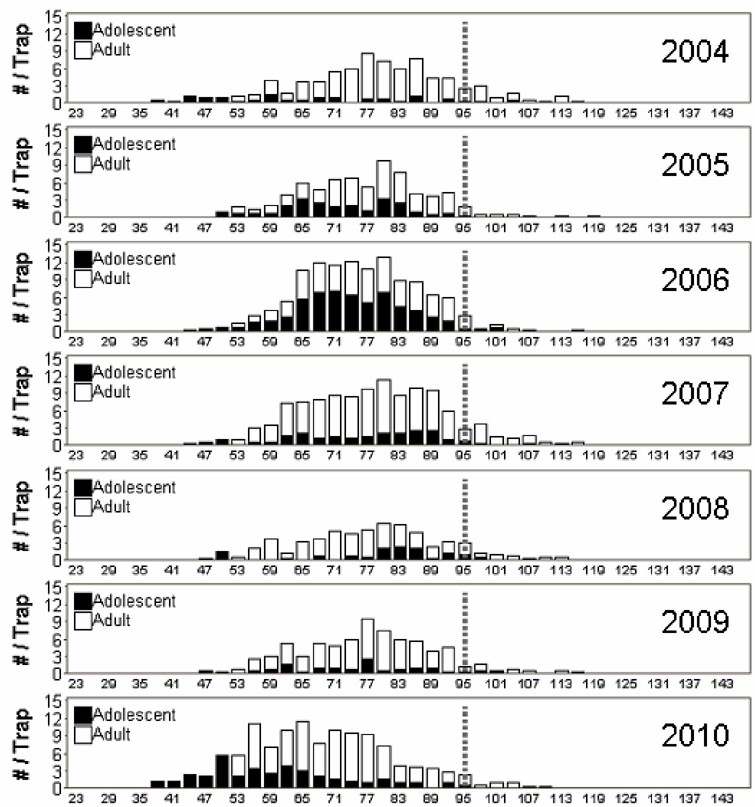


Figure 99: Trends in male carapace width distributions from small-mesh traps in CMA 3C from the CPS survey. The vertical dashed line indicates the minimum legal size.

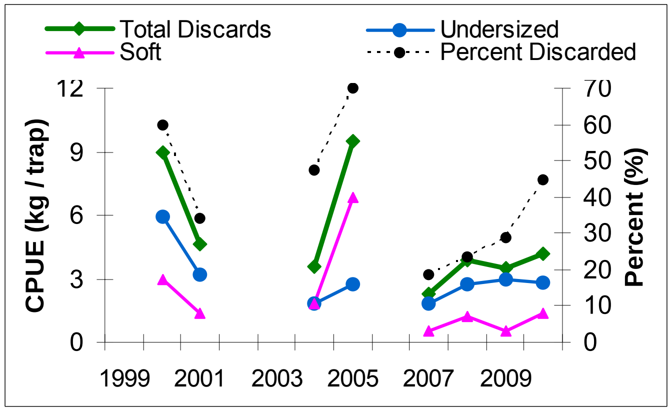


Figure 100: Trends in CMA 3C observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

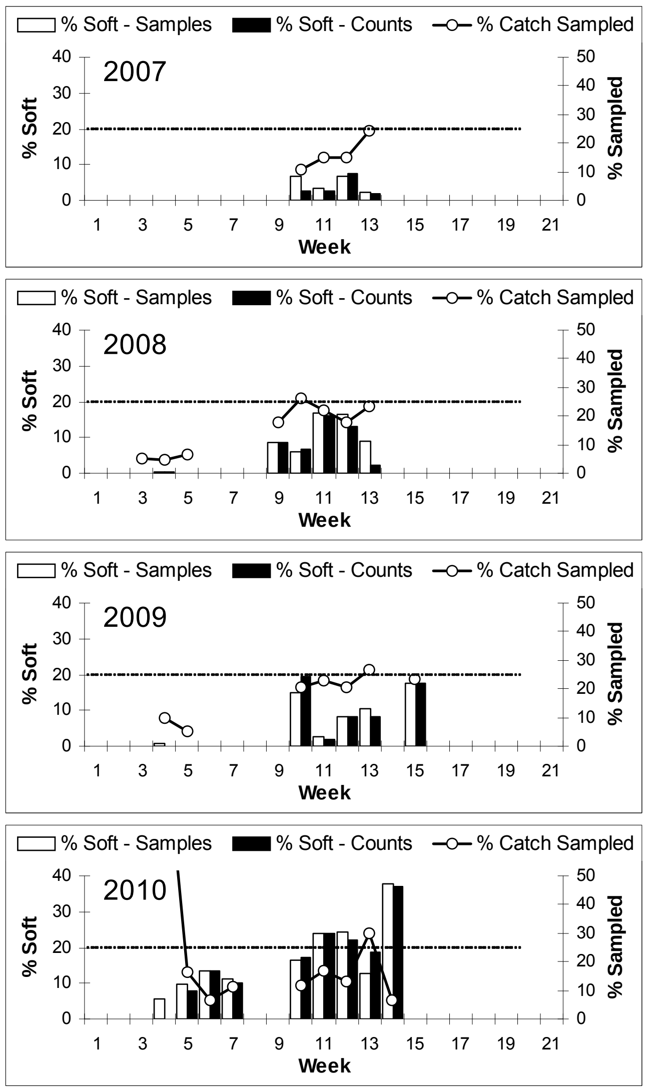


Figure 101: Trends in weekly percentages of soft-shell crab monitored and sampled in CMA 3C from 2007-2010.

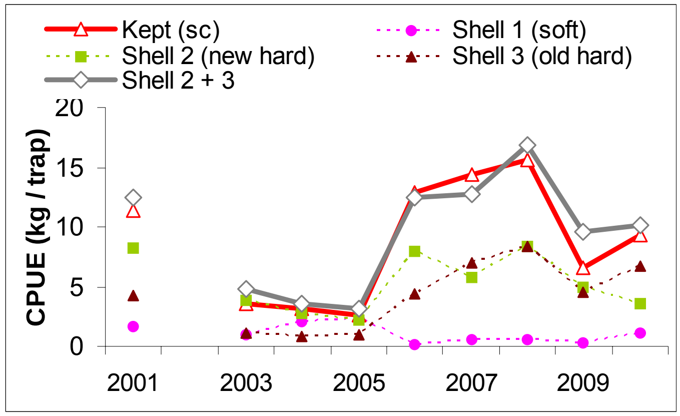


Figure 102: Trends in CMA 3D observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

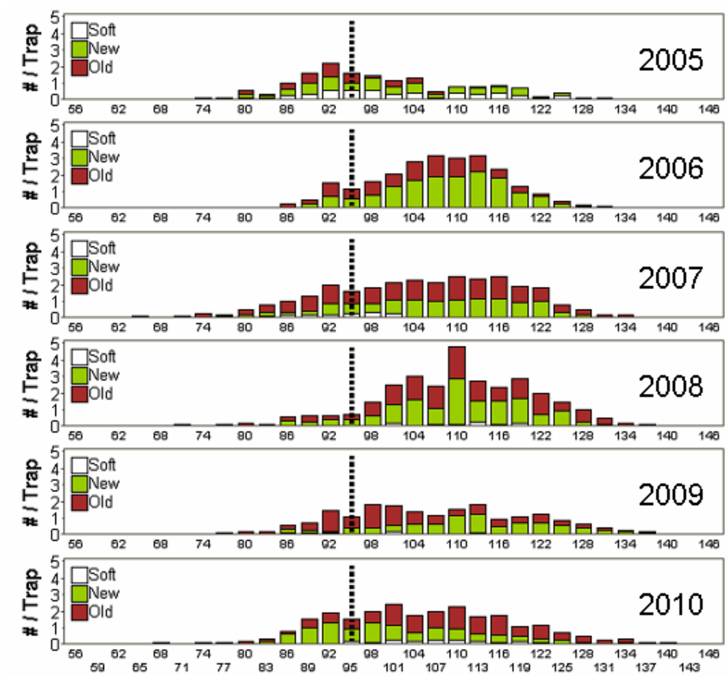


Figure 103: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 3D. The vertical dashed line indicates the minimum legal size.

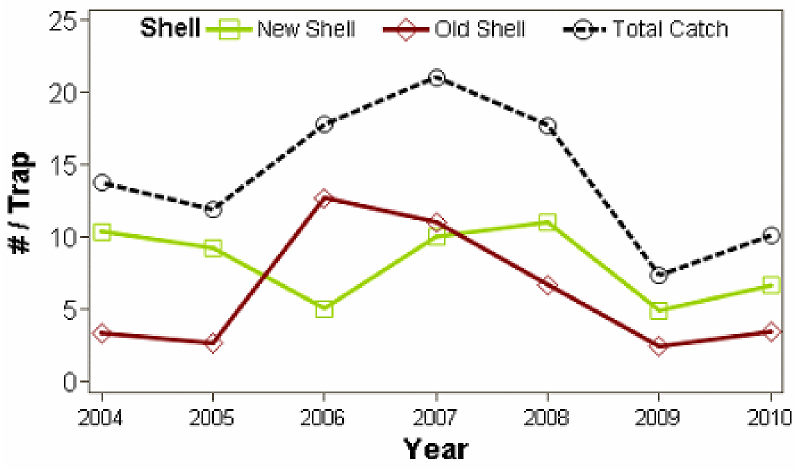


Figure 104: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 3D.

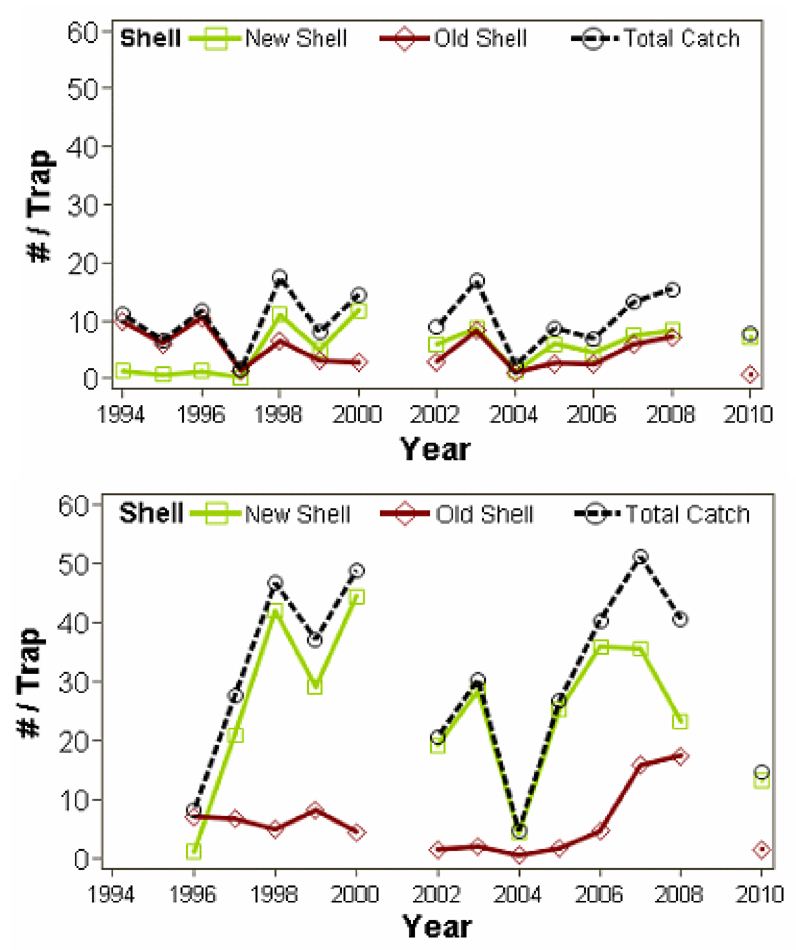


Figure 105: Trends in CPUE by shell condition for legal-sized crabs from strata occupied in the DFO trap survey in Notre Dame Bay. No surveys conducted in 2001 or 2009.

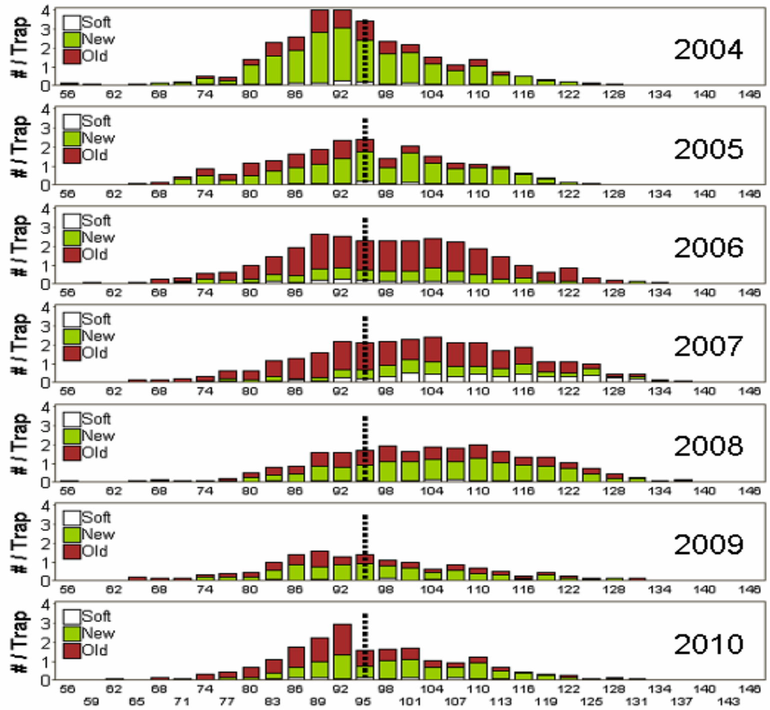


Figure 106: Trends in male carapace width distributions from core stations in CMA 3D from the CPS survey. The vertical dashed line indicates the minimum legal size.

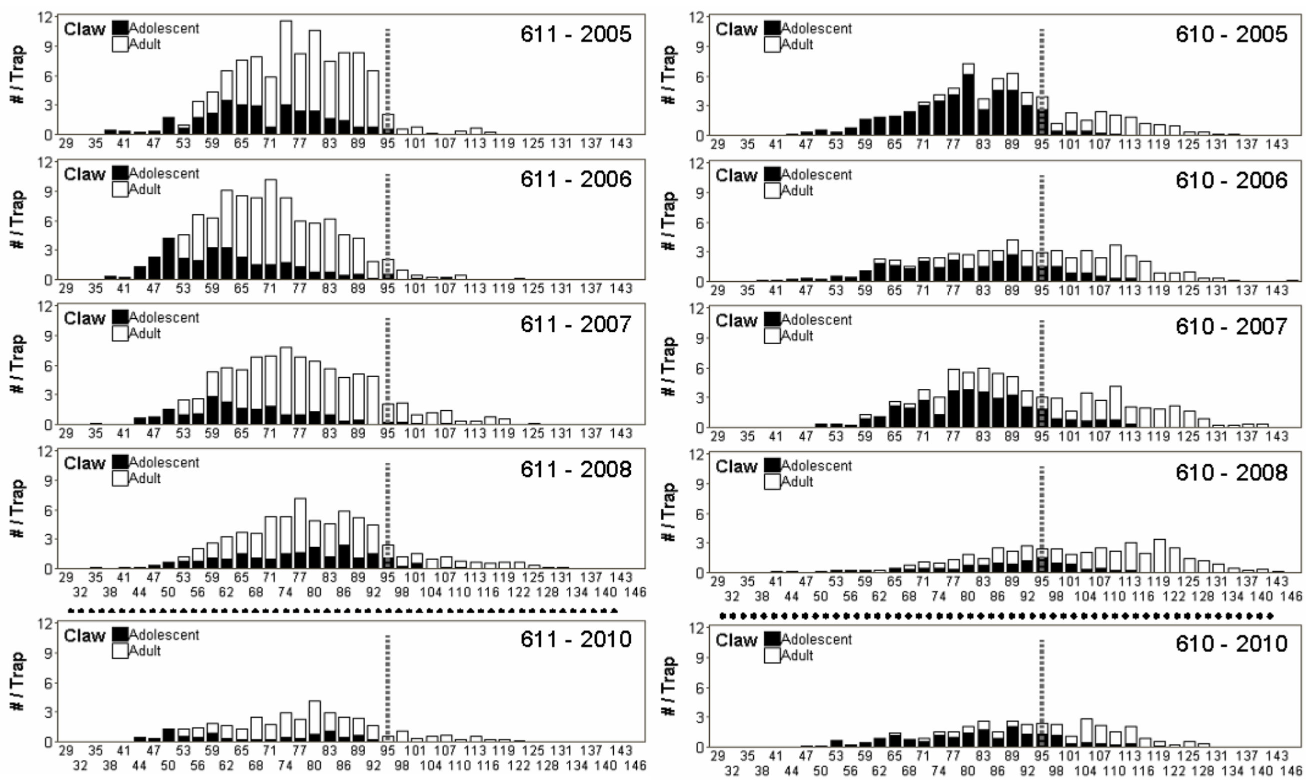


Figure 107: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in DFO trap survey in Notre Dame Bay from 2005-2010. The vertical dashed line indicates the minimum legal size.

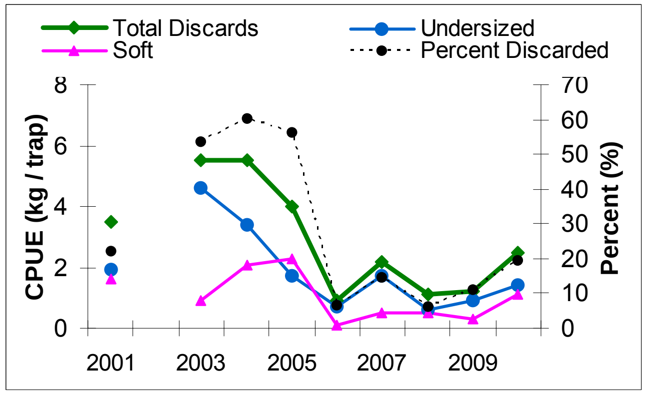


Figure 108: Trends in CMA 3D observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

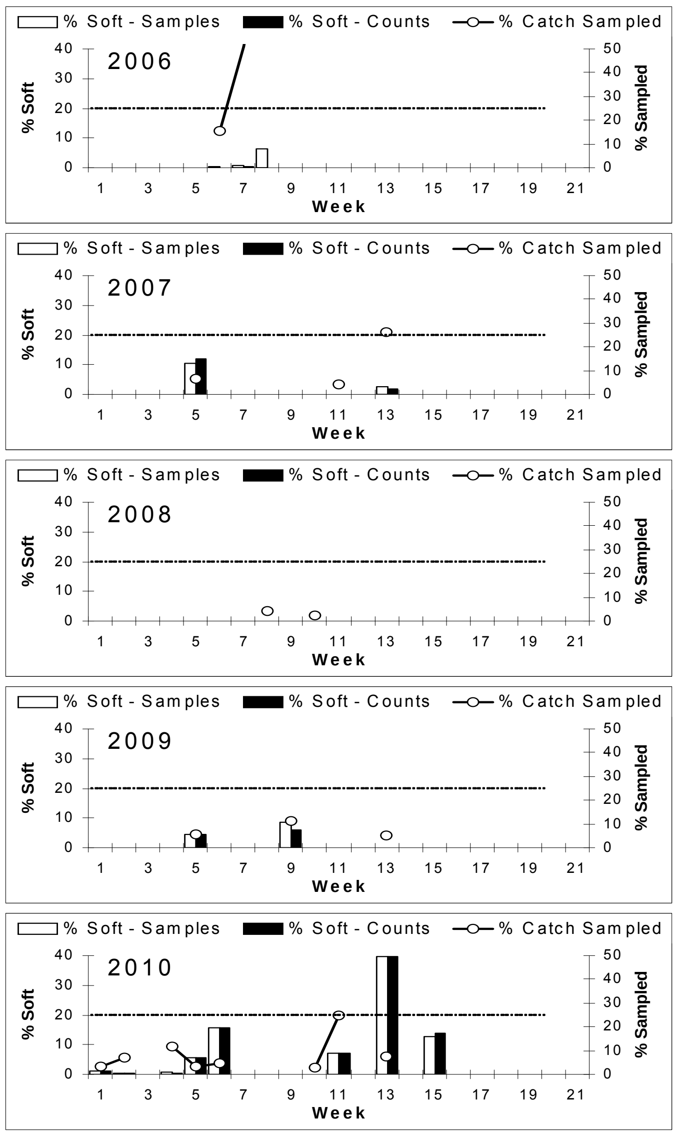


Figure 109: Trends in weekly percentages of soft-shell crab monitored and sampled in CMA 3D from 2006-2010.

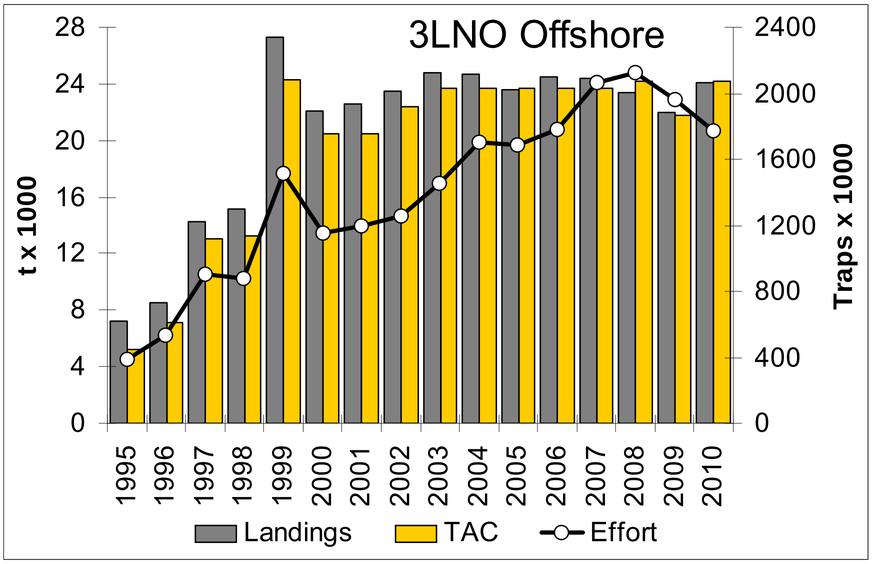


Figure 110: Trends in Div. 3LNO offshore landings, TAC, and fishing effort.

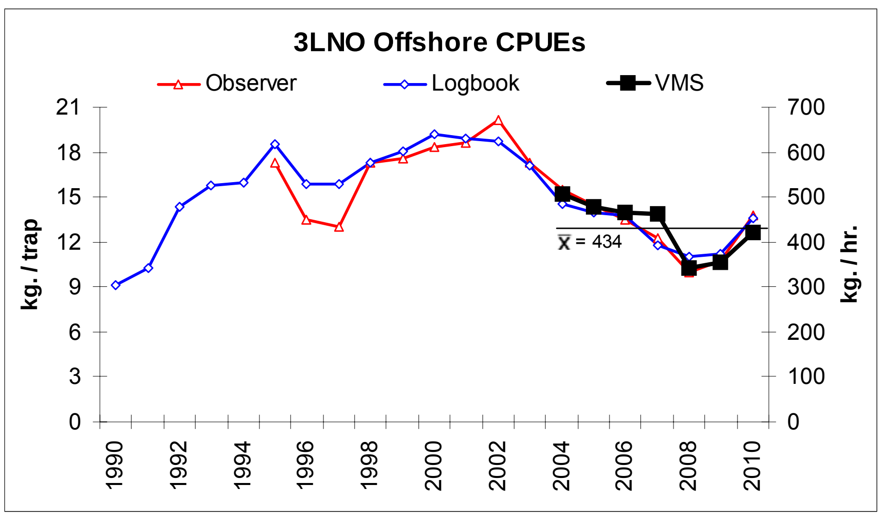


Figure 111: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Div. 3LNO offshore fishery. Solid black line denotes long-term VMS CPUE average.

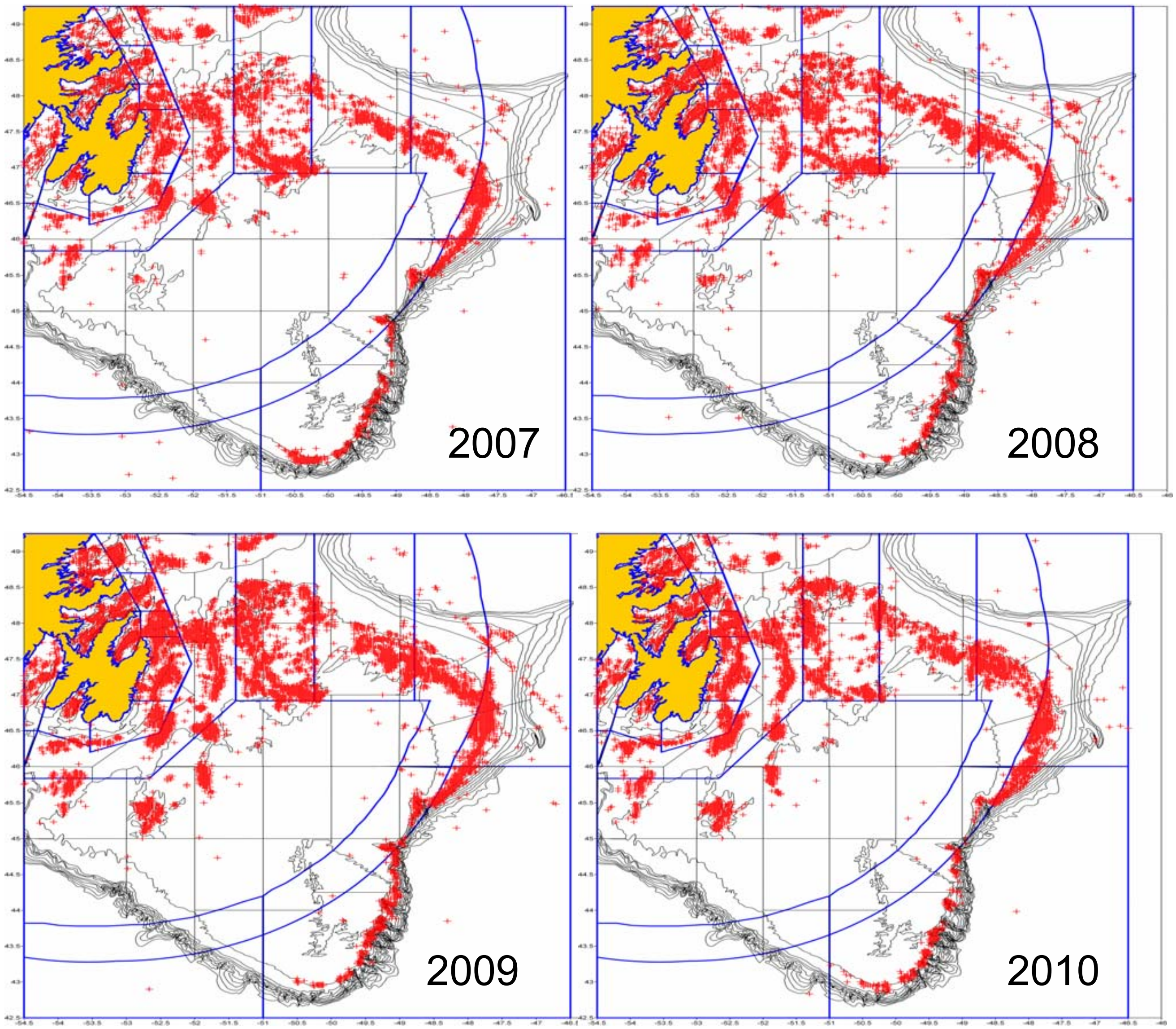


Figure 112: Spatial distribution of Div. 3LNO fishing effort by year.

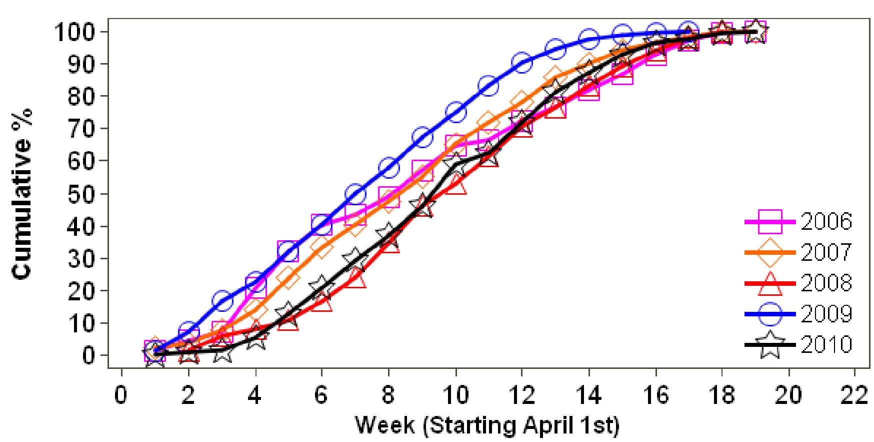


Figure 113: Seasonal trends in fishing effort for Div. 3LNO offshore during 2006-2010.

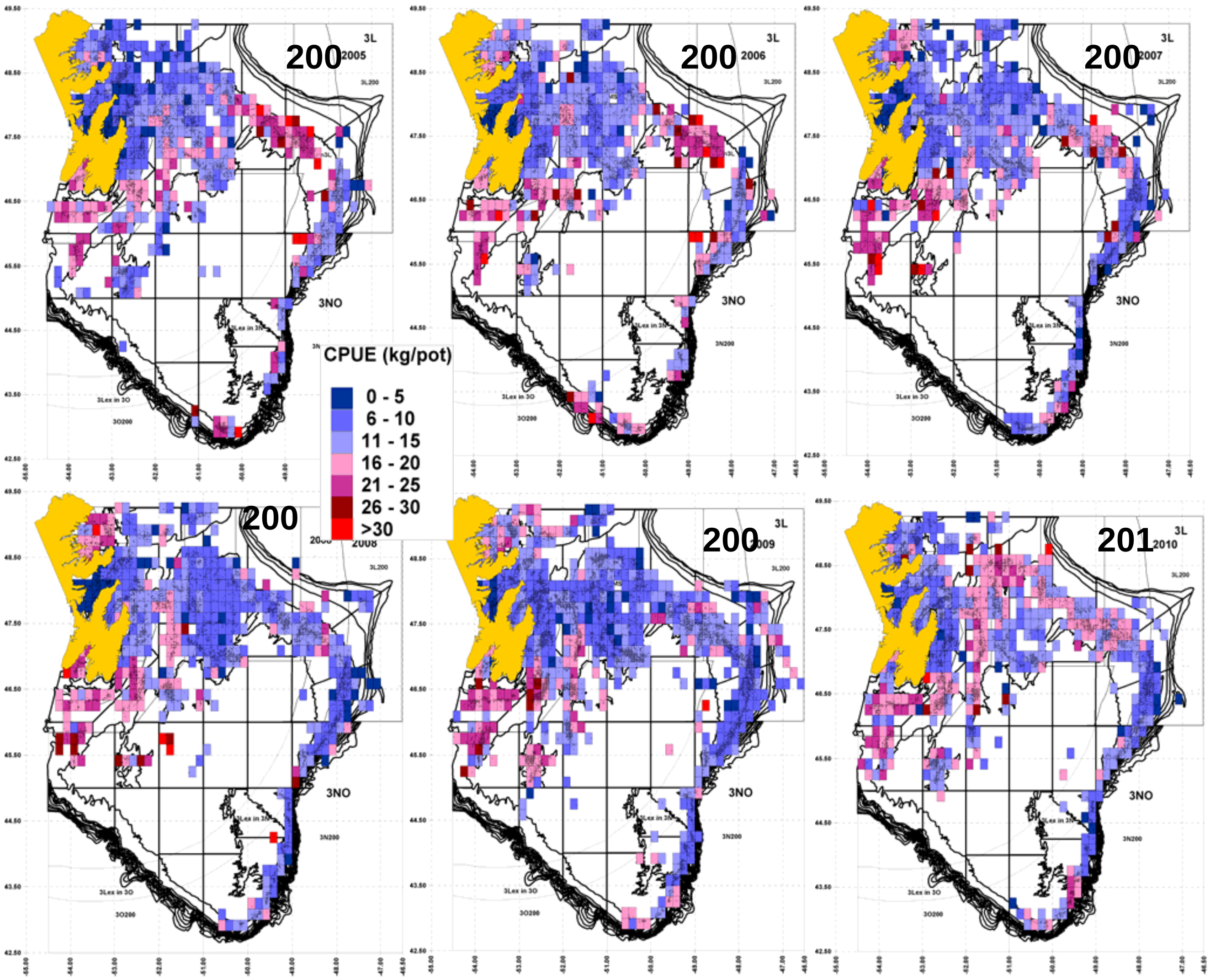


Figure 114: Spatial distribution of Div. 3LNO logbook CPUE by year.

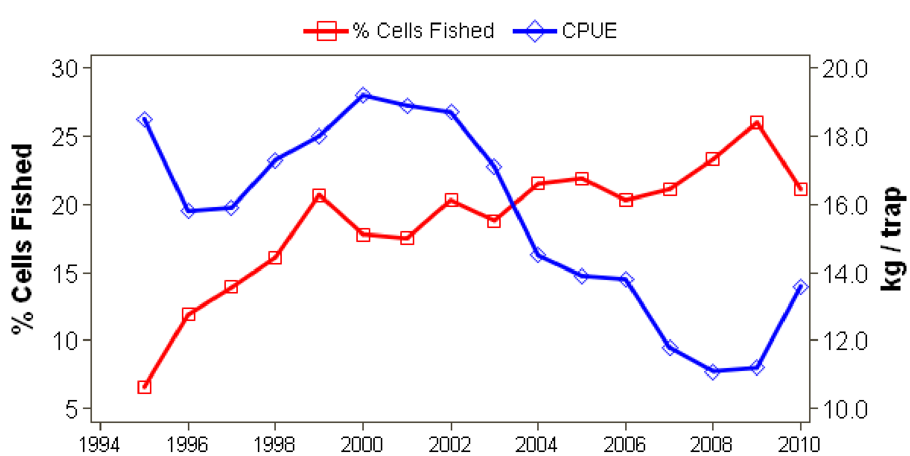


Figure 115: Trends in Div. 3LNO offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

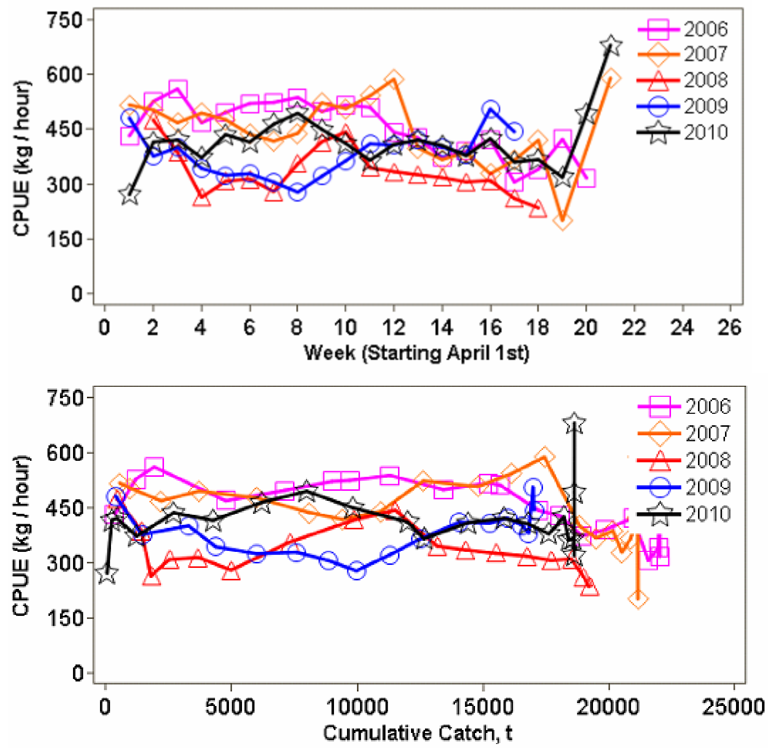


Figure 116: Seasonal trends in VMS-based CPUE for Div. 3LNO offshore during 2006-2010; (above) by week, and (below) in relation to cumulative catch.

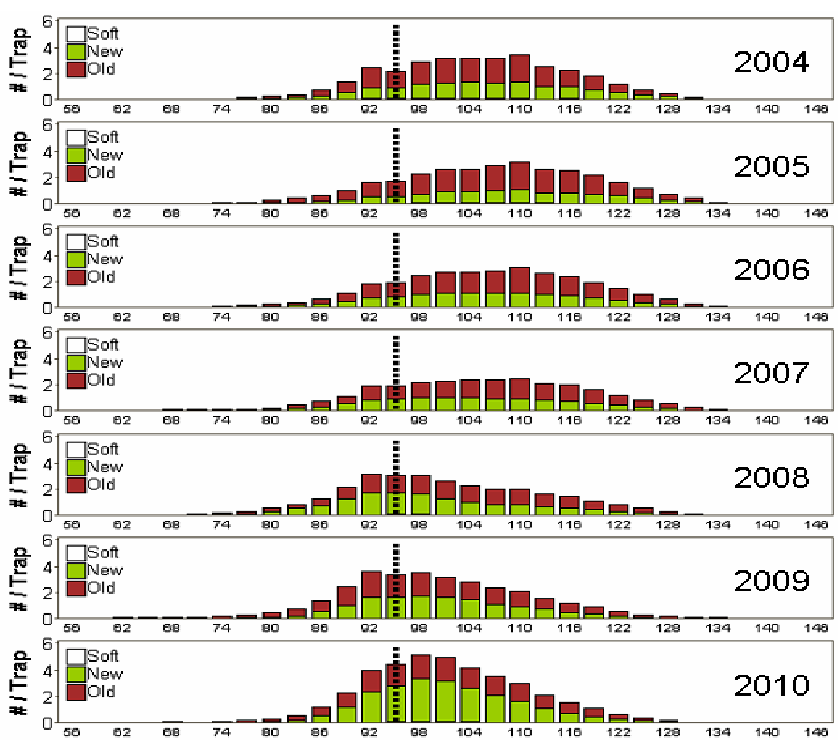


Figure 117: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Div. 3LNO offshore. The vertical dashed line indicates the minimum legal size.

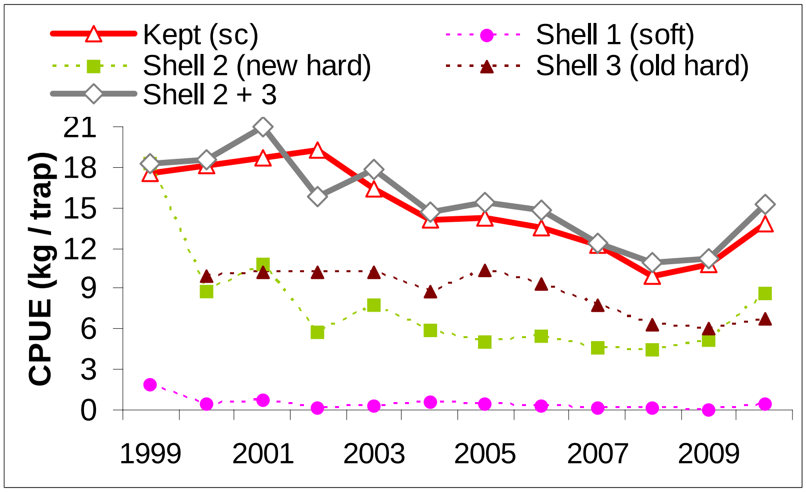


Figure 118: Trends in Division 3LNO offshore observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

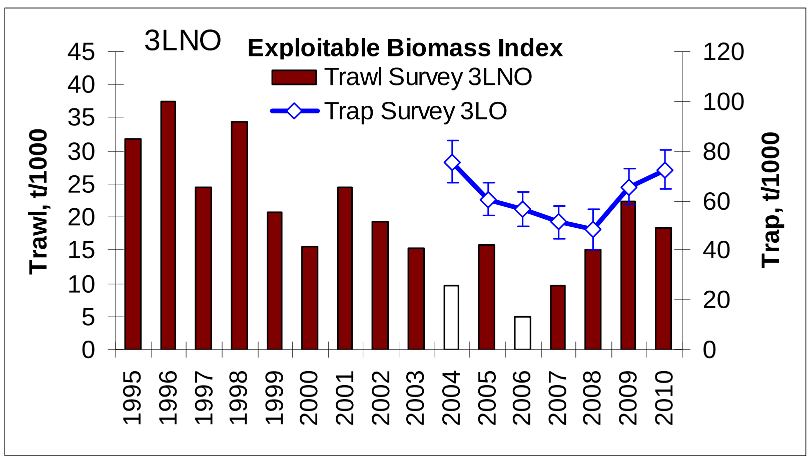


Figure 119: Trends in the Div. 3LNO offshore fall trawl survey exploitable biomass index and the CPS trap survey biomass index. The trawl survey was incomplete in 2004 and 2006.

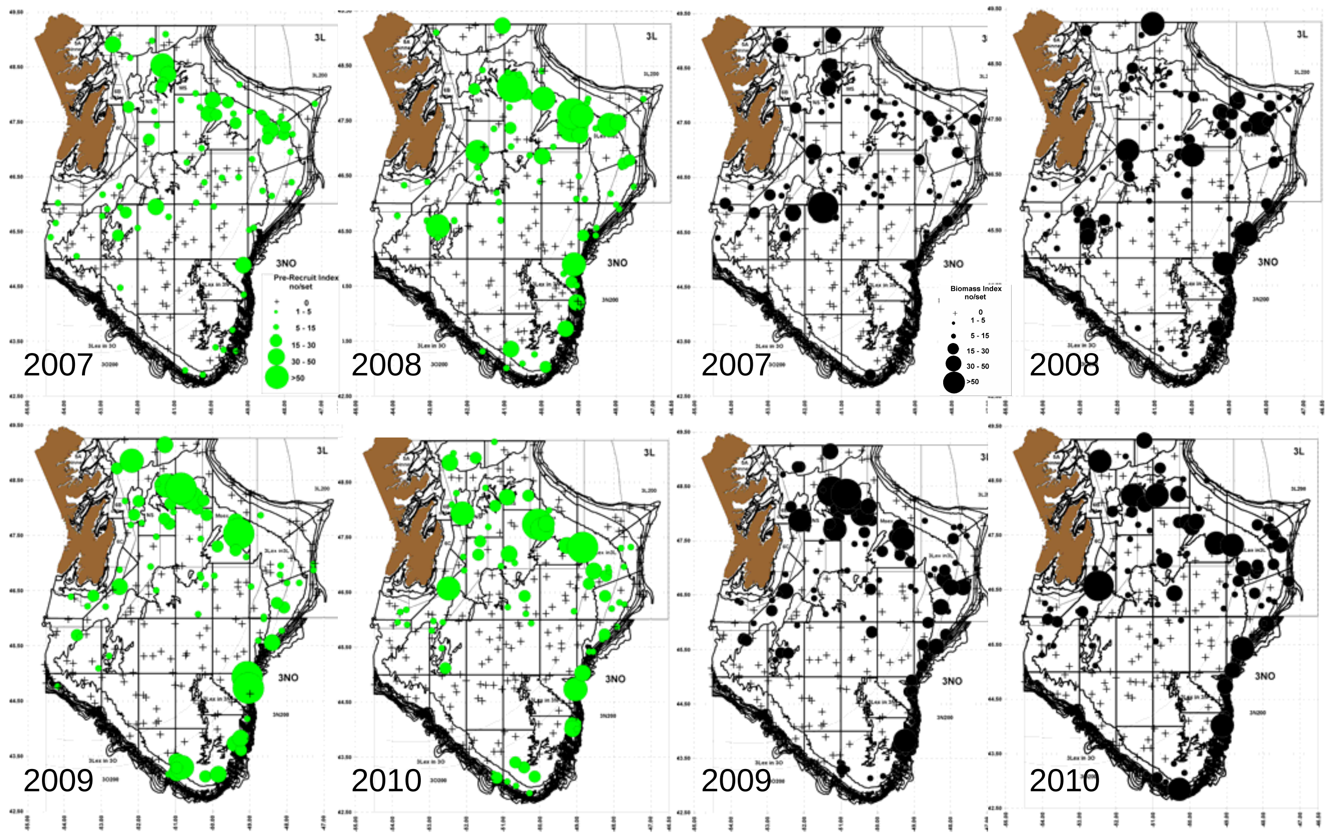


Figure 120: Spatial distribution of catches (number / set) or pre-recruit and exploitable snow crab in the Div. 3LNO offshore trawl survey.

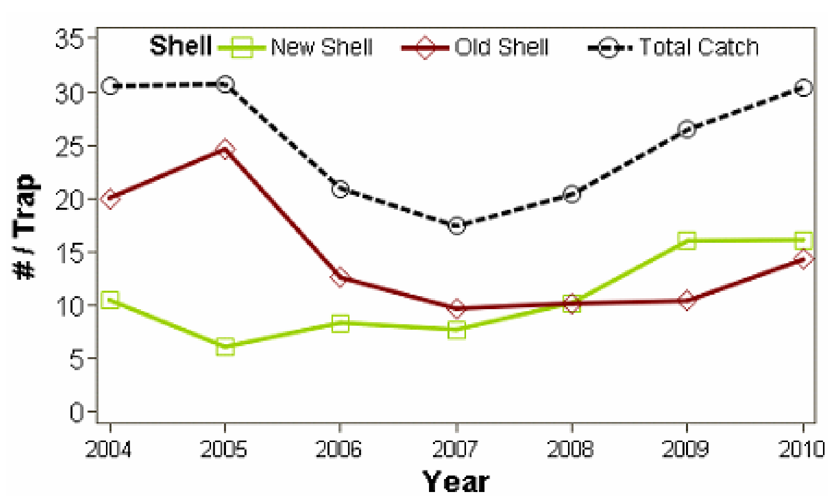


Figure 121: Trends in CPUE by shell condition for legal-sized crabs from core stations in the Div. 3LNO offshore CPS trap survey.

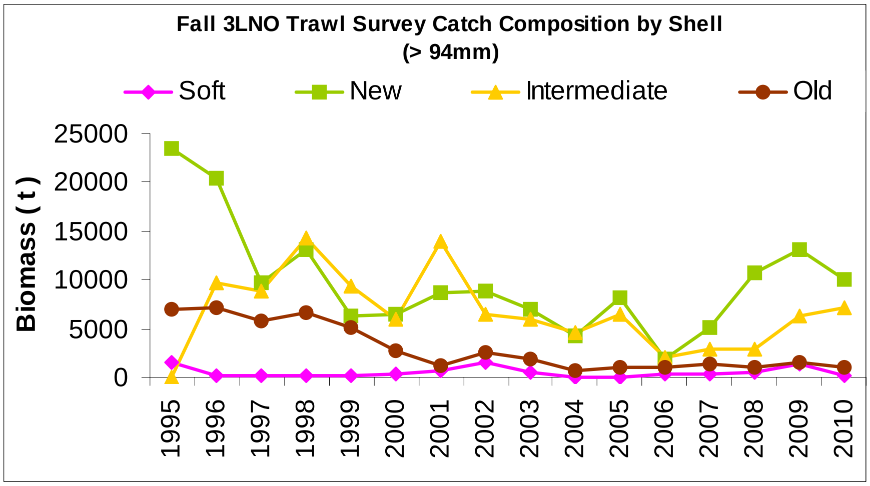


Figure 122: Trends, by shell condition, in biomass of legal-sized males for Div. 3LNO offshore from fall trawl surveys.

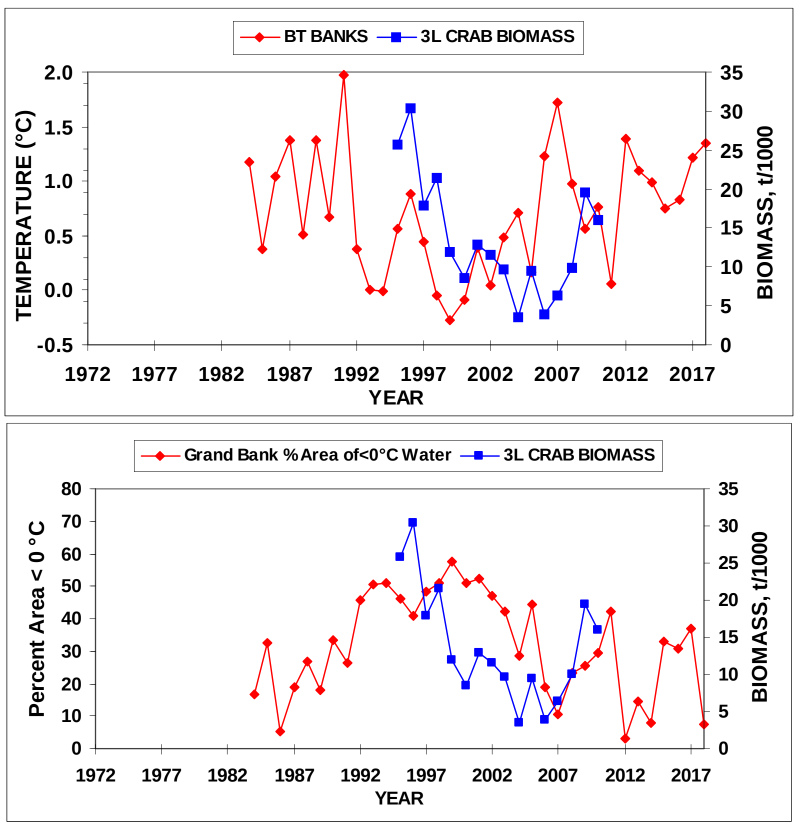


Figure 123: Trends in the Div. 3L offshore exploitable biomass index vs. bottom temperature at an eight year lag (above) and vs. the spatial extent of the cold intermediate layer at an eight year lag (below).

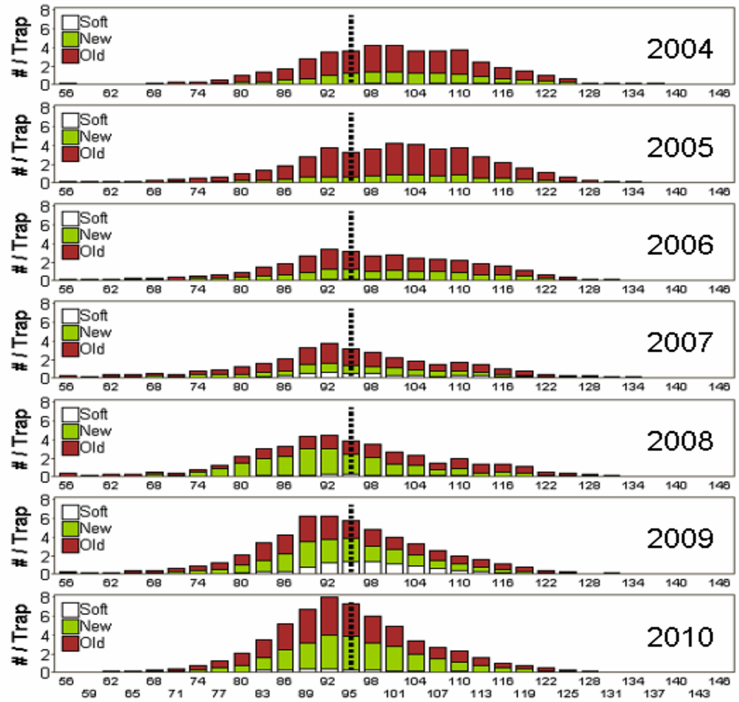


Figure 124: Trends in male carapace width distributions from core stations in the Div. 3LNO offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

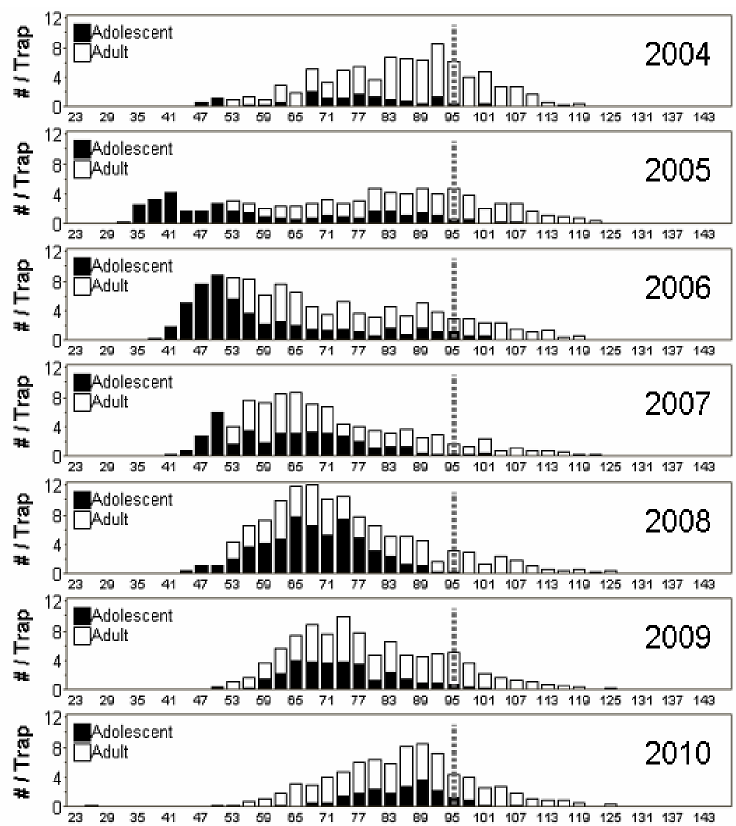


Figure 125: Trends in male carapace width distributions from small-mesh traps in the Div. 3LNO offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

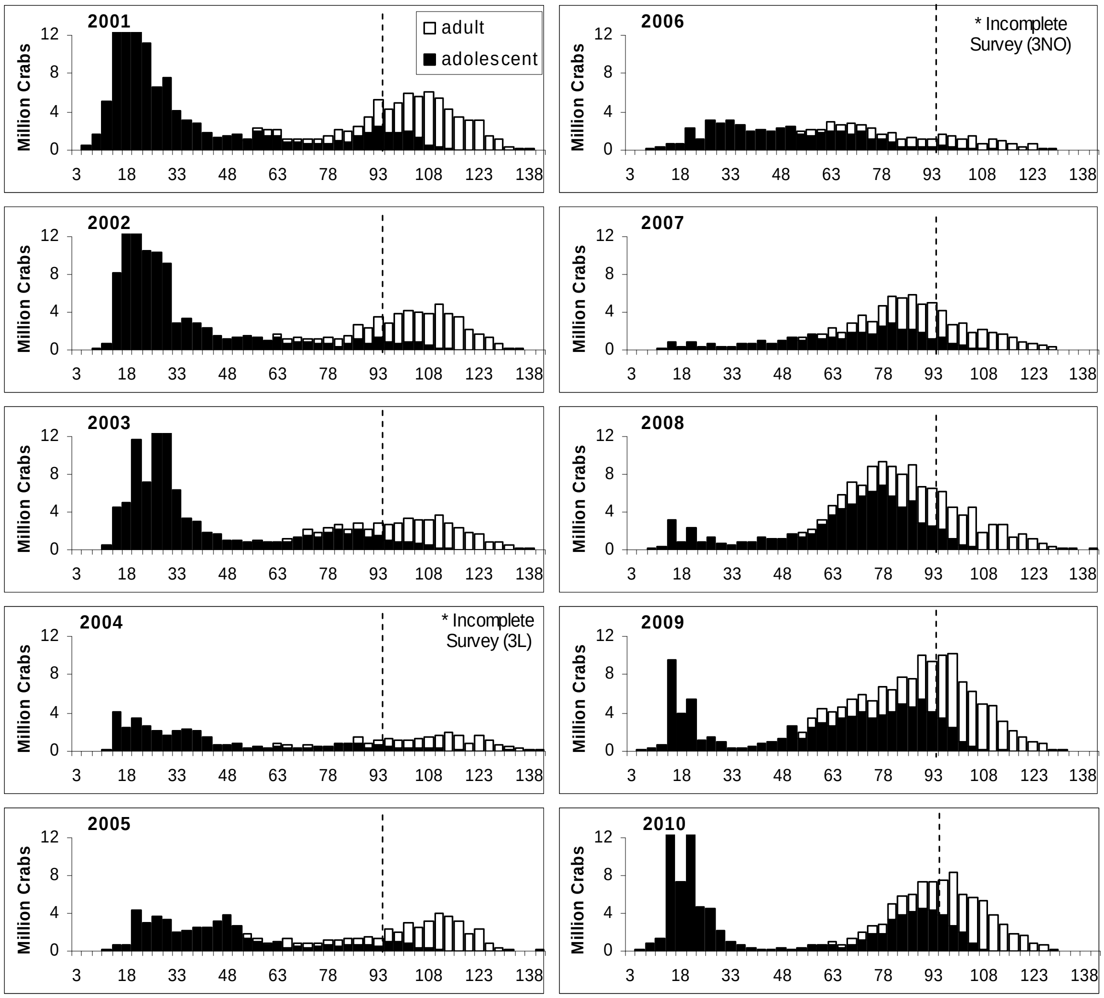


Figure 126: Abundance indices by carapace width for Div. 3LNO juveniles plus adolescents (dark bars) versus adults (open bars) from fall trawl surveys. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line.

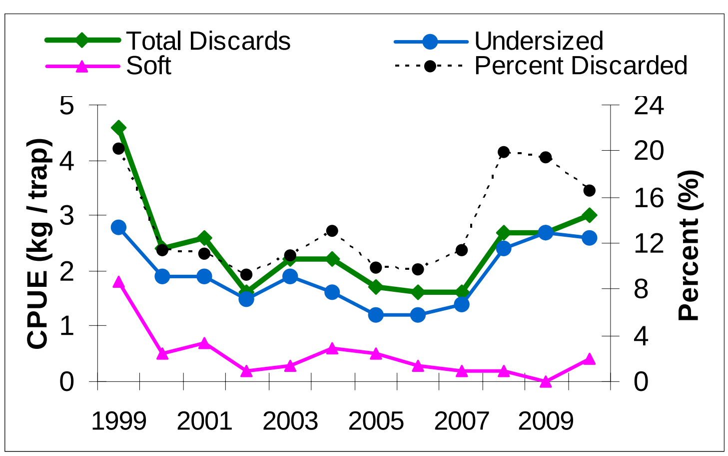


Figure 127: Trends in Division 3LNO offshore observer catch rates of total discards, under-sized discards, and legal-sized discards, as well as the percentage of the catch discarded.

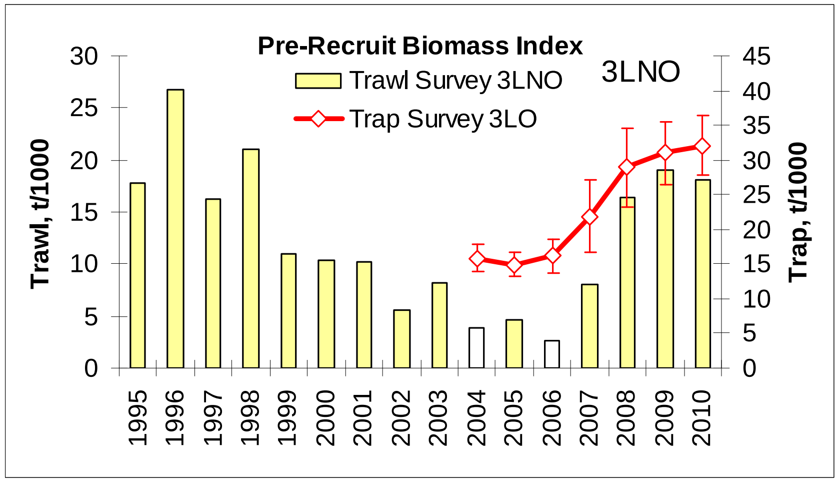


Figure 128: Trends in the Div. 3LNO fall trawl survey pre-recruit biomass index and the CPS trap survey biomass index. The trawl survey was incomplete in 2004 and 2006.

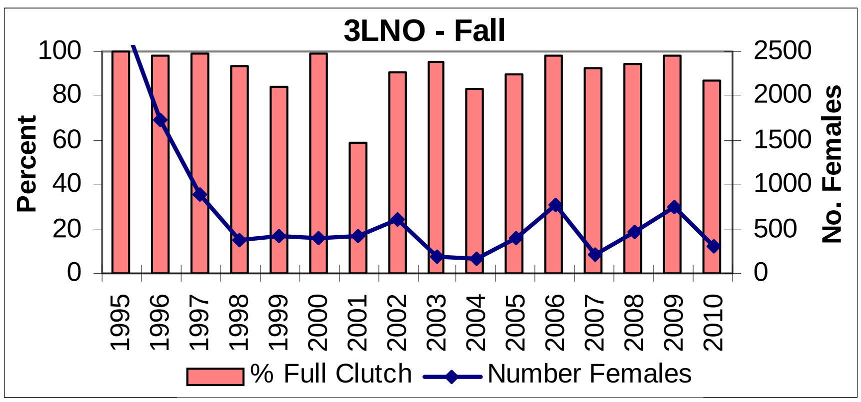


Figure 129: Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Div. 3LNO from fall multi-species surveys.

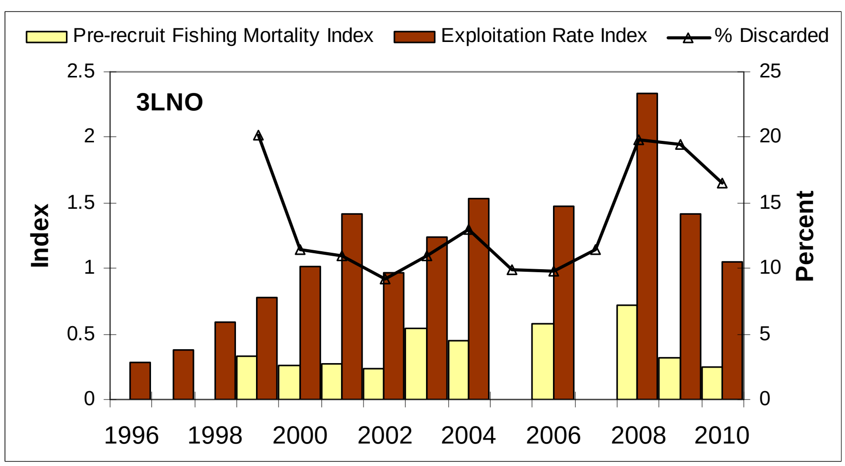


Figure 130: Trends in Div. 3LNO offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery (No 2005 or 2007 exploitation rate or pre-recruit fishing mortality indices because of an incomplete 2004 and 2006 surveys).

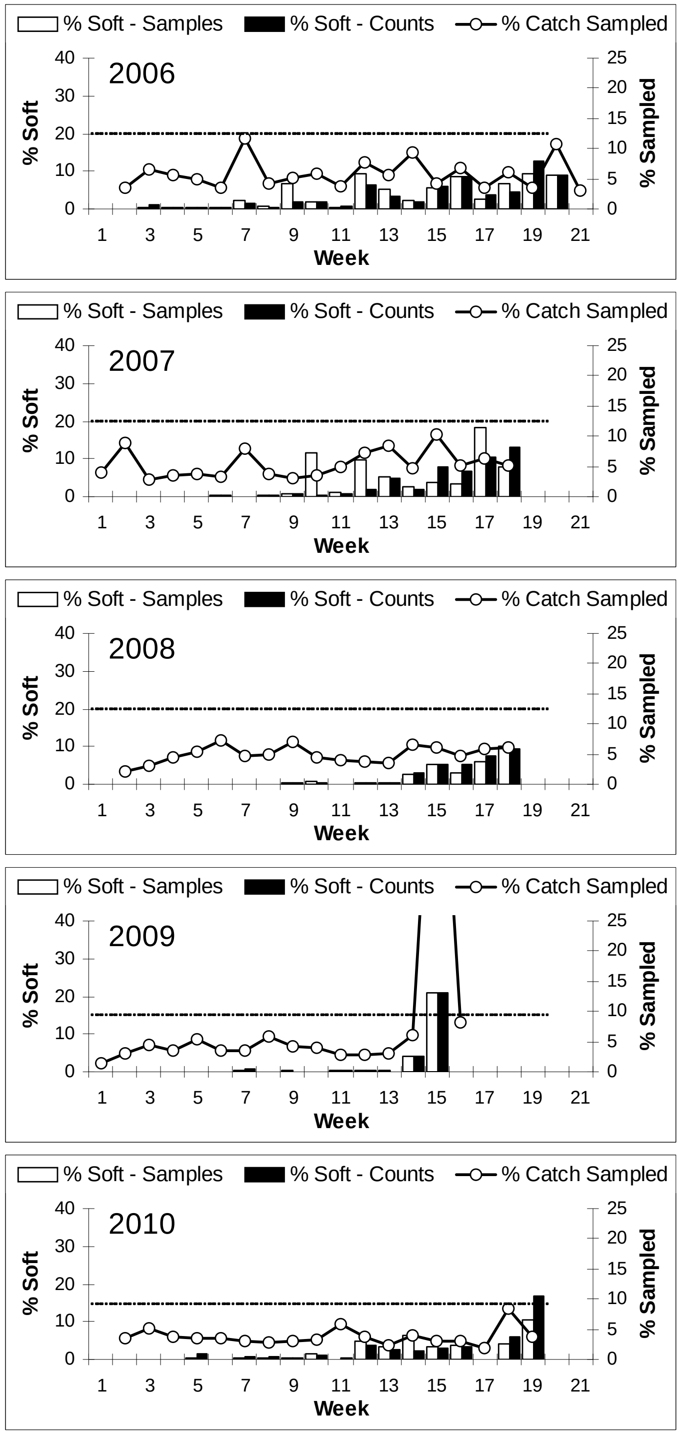


Figure 131: Trends in weekly percentages of soft-shell crab monitored and sampled in Div. 3LNO offshore from 2006-2010.

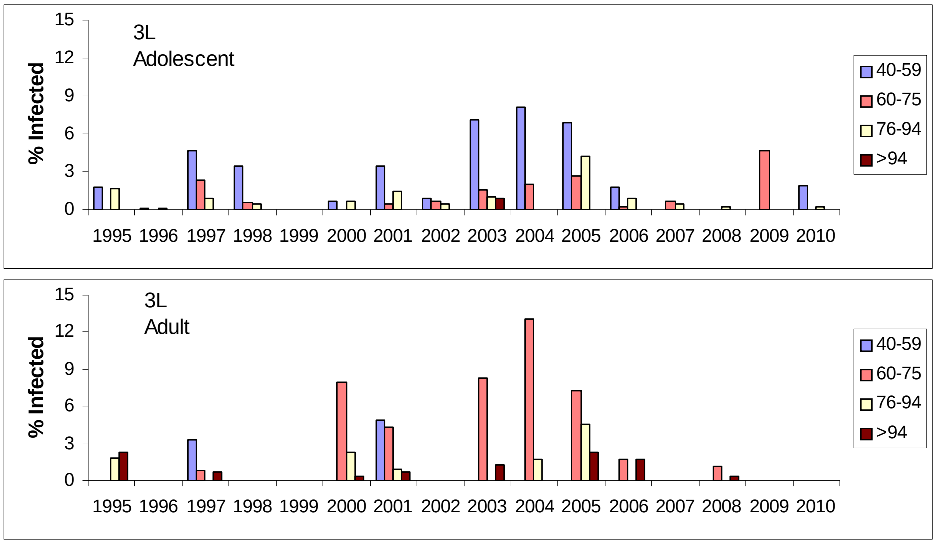


Figure 132: Trends in prevalence of BCD in new-shelled adolescents (above) and adults (below) by male size group from Div. 3L fall trawl surveys.

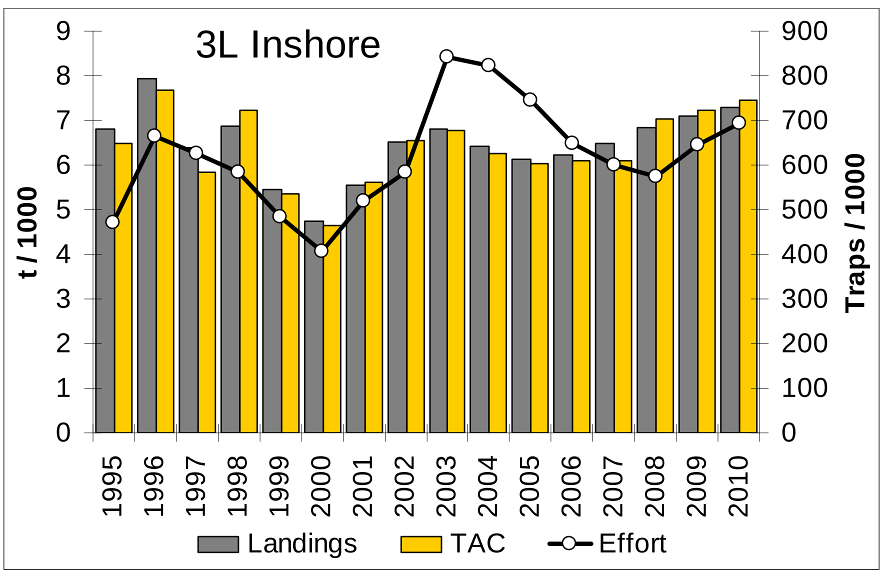


Figure 133: Trends in Div. 3L inshore landings, TAC, and fishing effort.

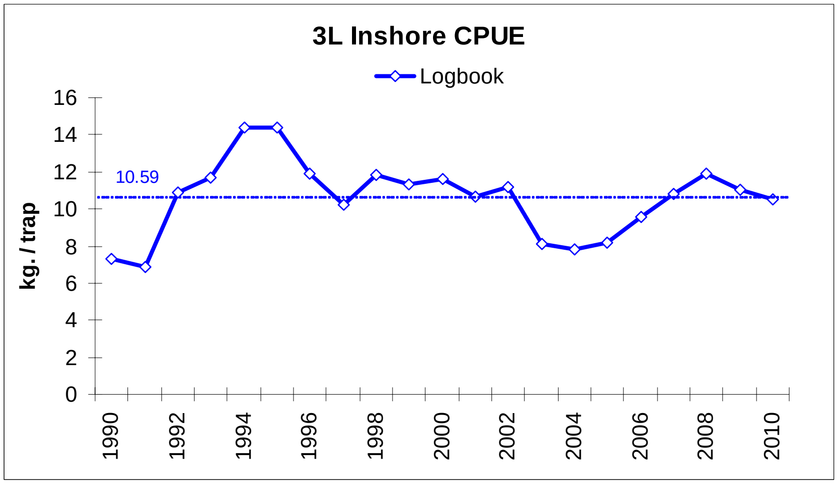


Figure 134: Trends in commercial logbook-based CPUE in the Div. 3K inshore fishery.

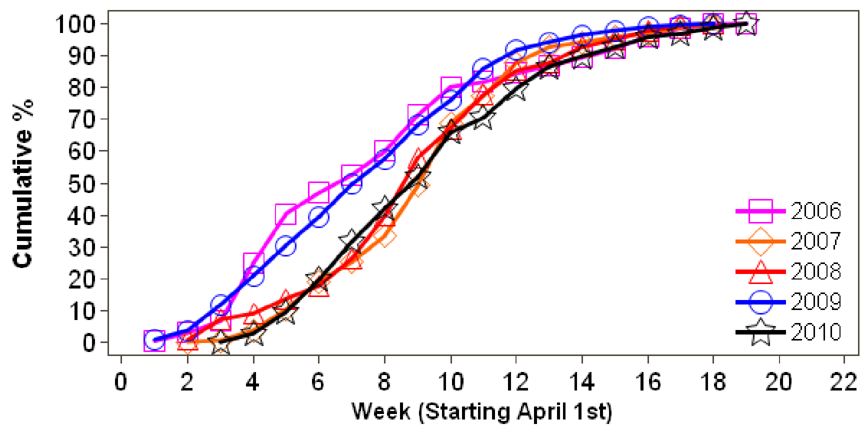


Figure 135: Seasonal trends in weekly fishing effort for Div. 3L inshore during 2006-2010.

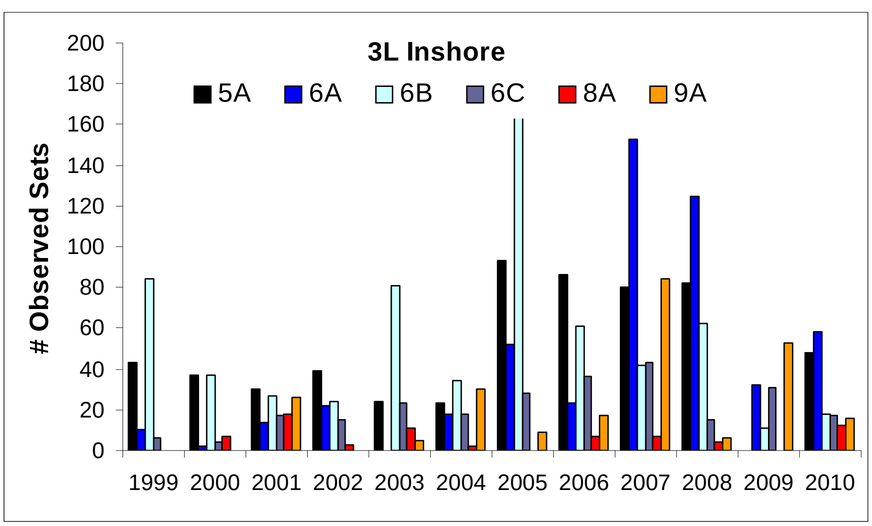


Figure 136: Trends in number of observed sets by Crab Management Areas and year in Division 3L inshore.

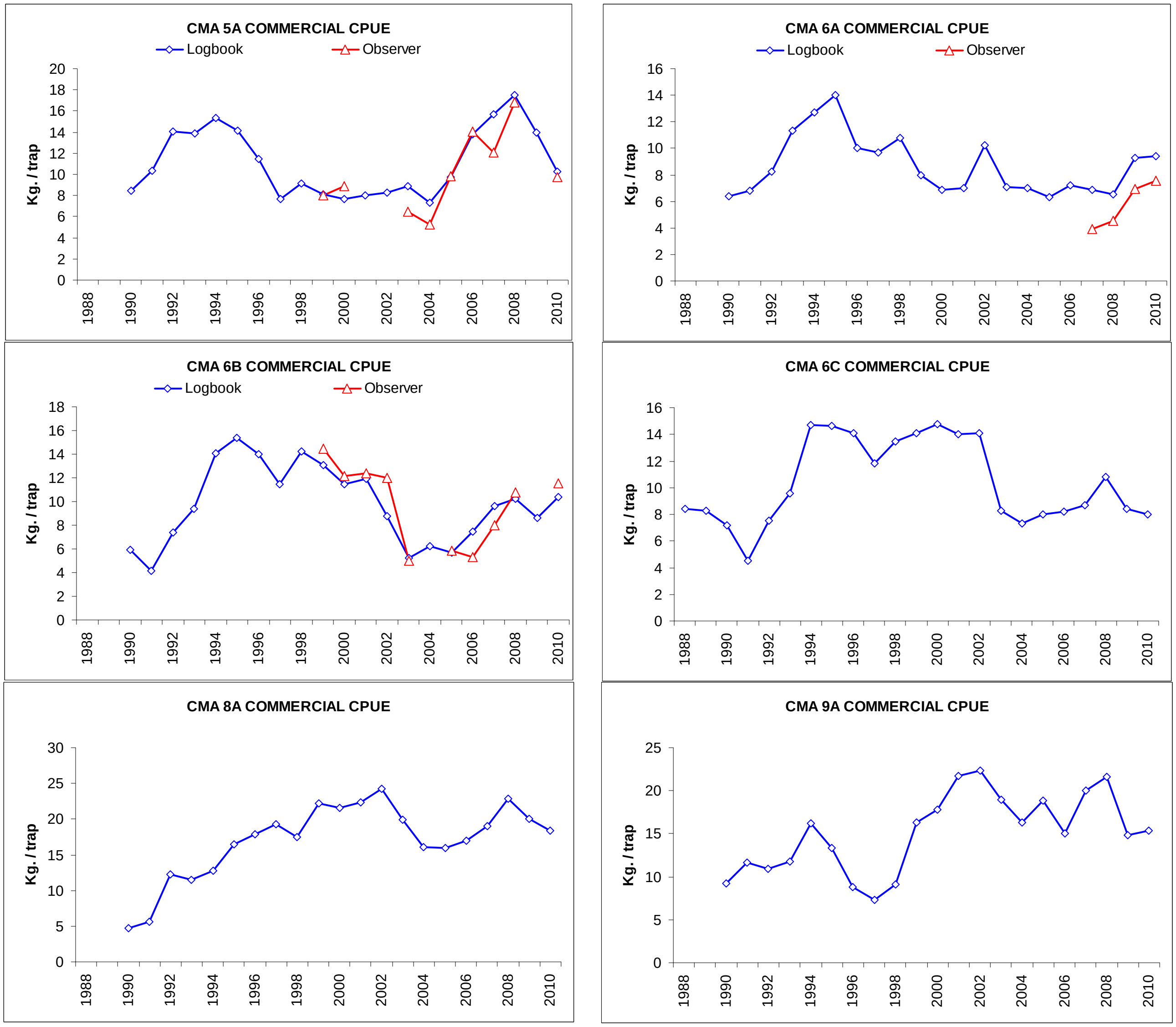


Figure 137: Trends in Division 3K inshore logbook CPUE and observer CPUE by Crab Management Area.

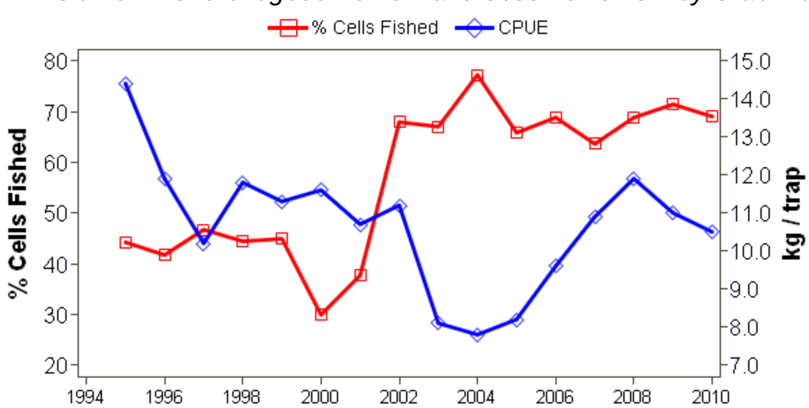


Figure 138: Trends in Div. 3L inshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

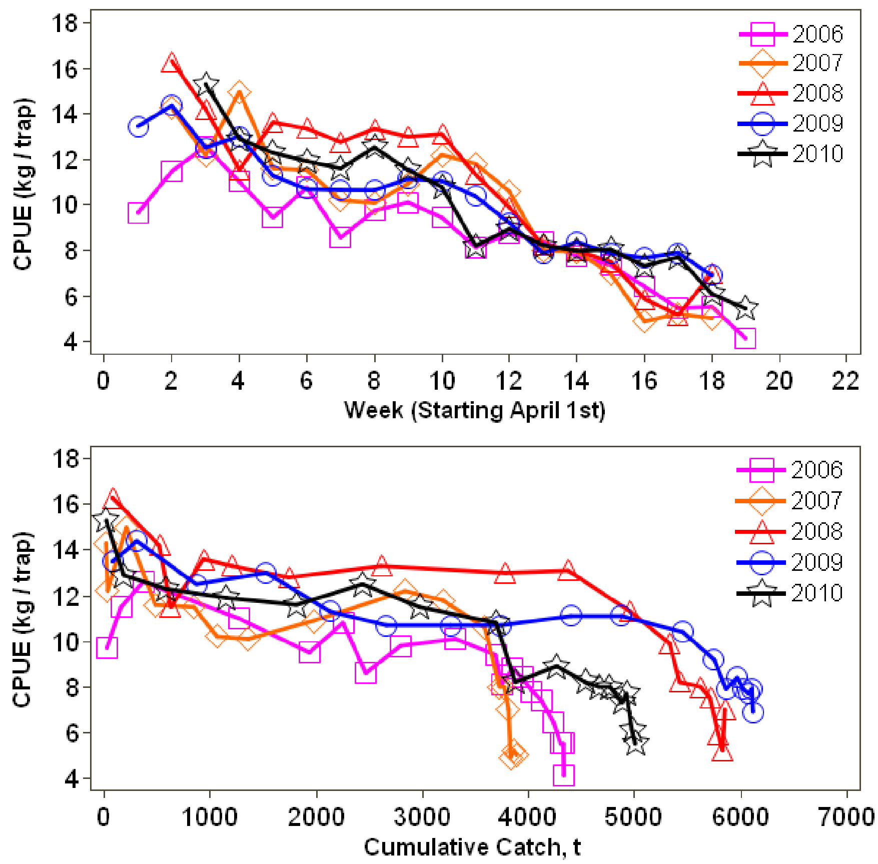


Figure 139: Seasonal trends in logbook-based CPUE for Div. 3L inshore during 2006-2010; (above) by week, and (below) in relation to cumulative catch.

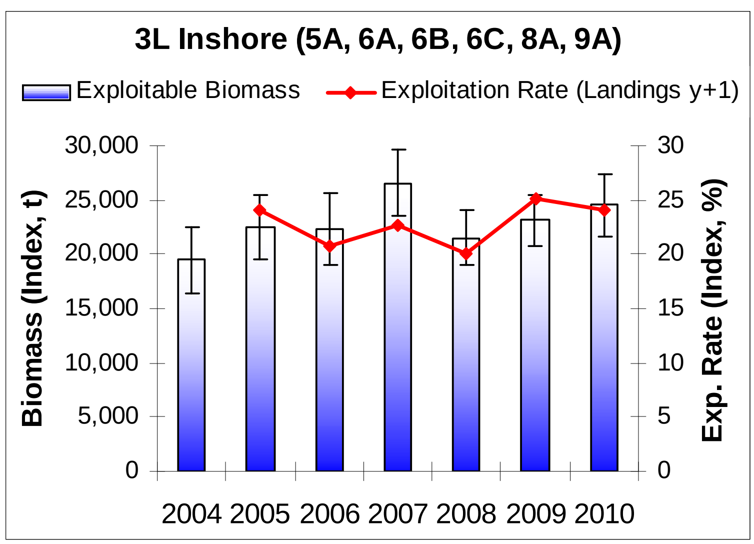


Figure 140: Exploitable biomass and exploitation rate indices from the CPS trap survey in Division 3L inshore.

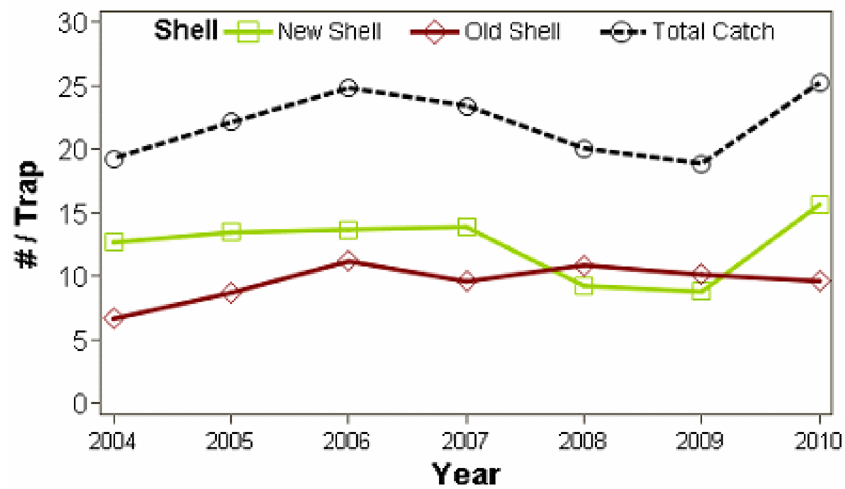


Figure 141: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Div. 3L inshore.

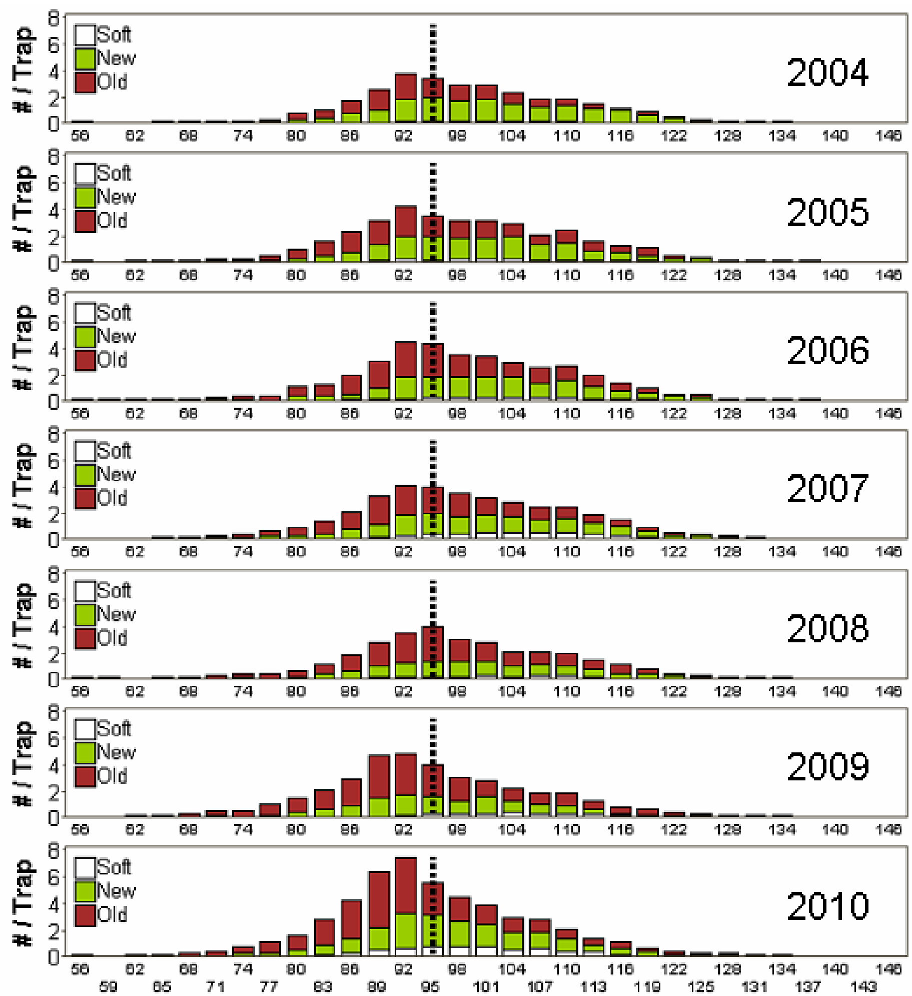


Figure 142: Trends in male carapace width distributions from core stations in the Div. 3L inshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

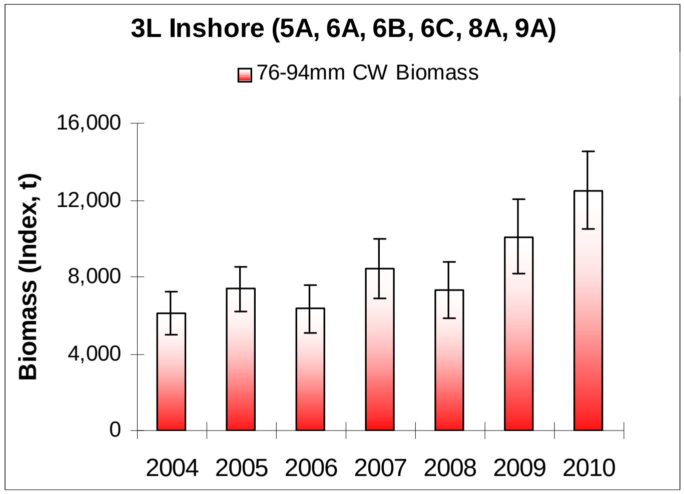


Fig. 143: Pre-recruit biomass index based on the CPS trap survey in Division 3L inshore.

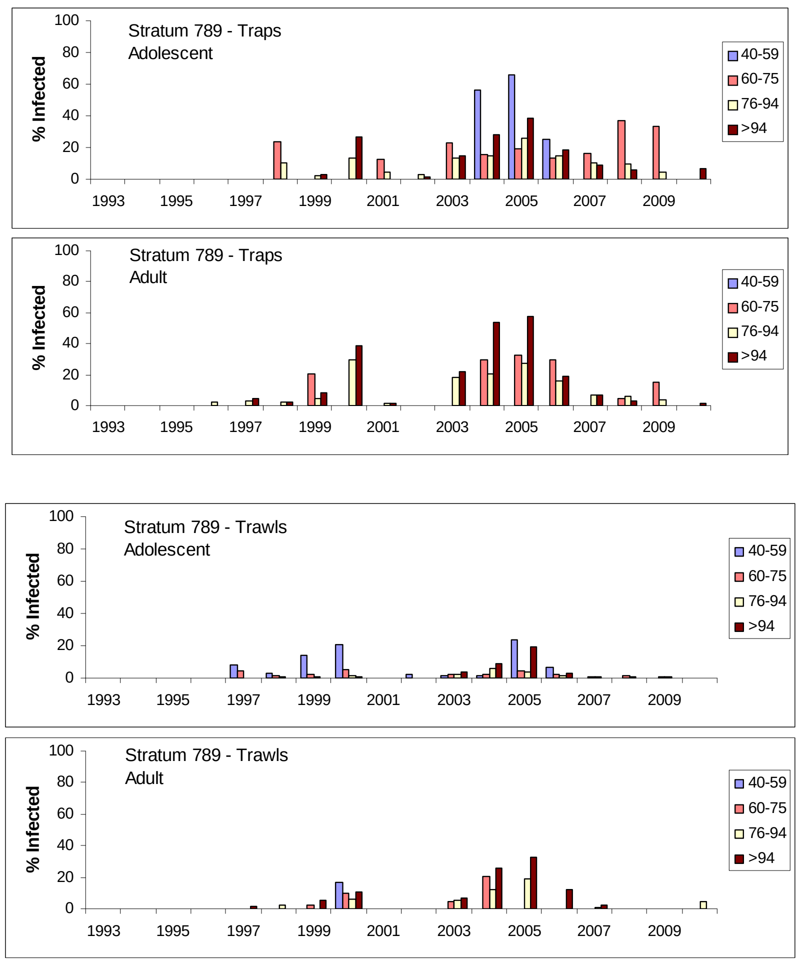


Fig. 144: Trends of prevalence of BCD in new-shelled males by stratum, year, and size group from DFO trap (above) and trawl (below) surveys in Conception Bay; adolescents presented above adults in both surveys.

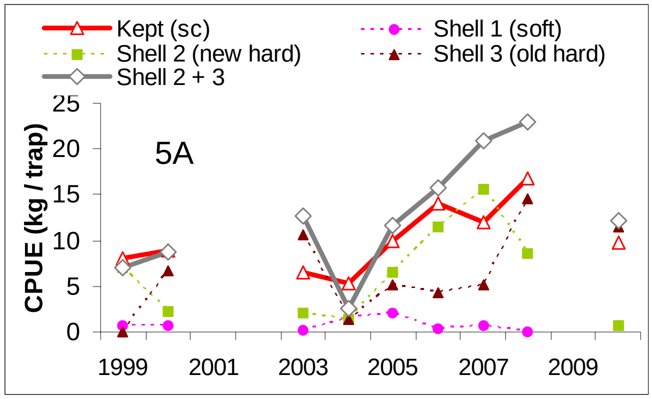


Figure 145: Trends in CMA 5A observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

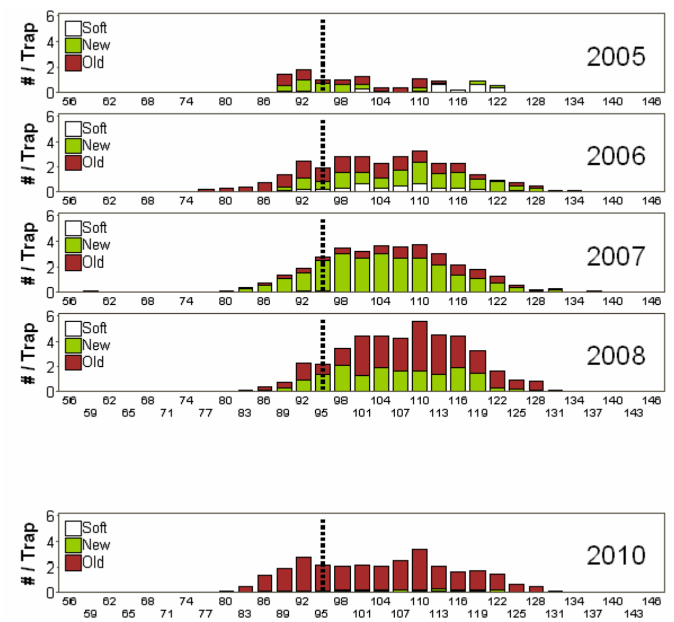


Figure 146: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 5A. The vertical dashed line indicates the minimum legal size.

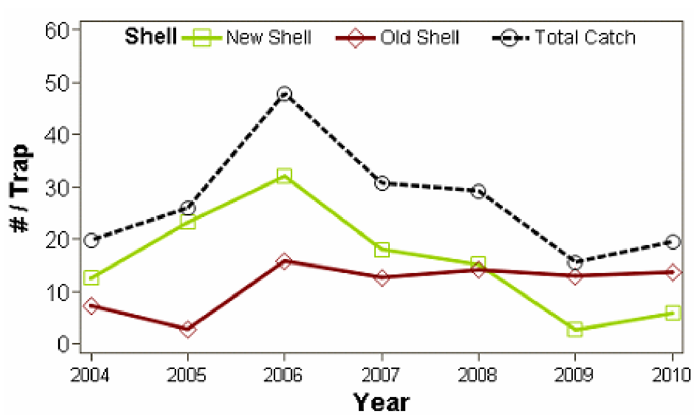


Figure 147: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 5A.

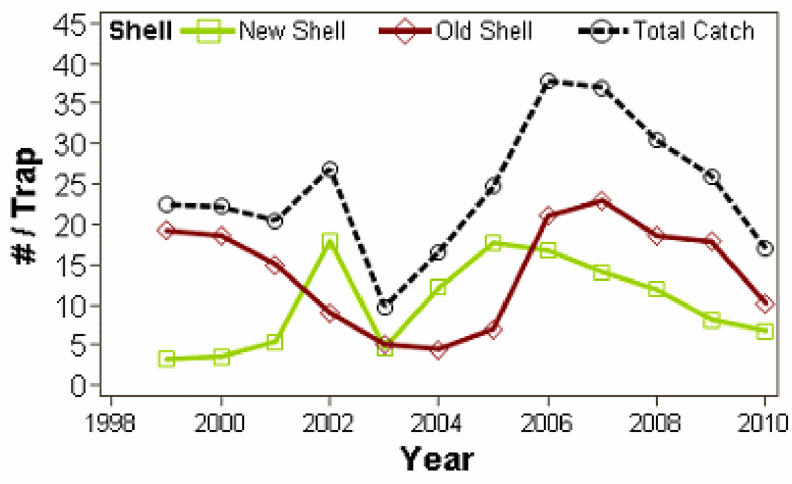


Figure 148: Trends in CPUE by shell condition for legal-sized crabs from the stratum occupied in the DFO trap survey in Bonavista Bay.

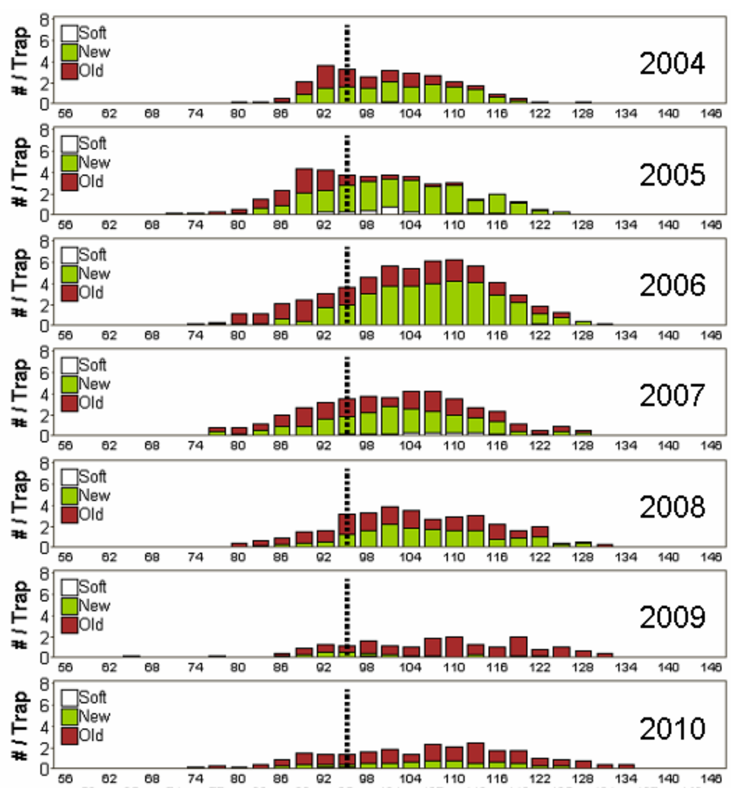


Figure 149: Trends in male carapace width distributions from core stations in CMA 5A from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

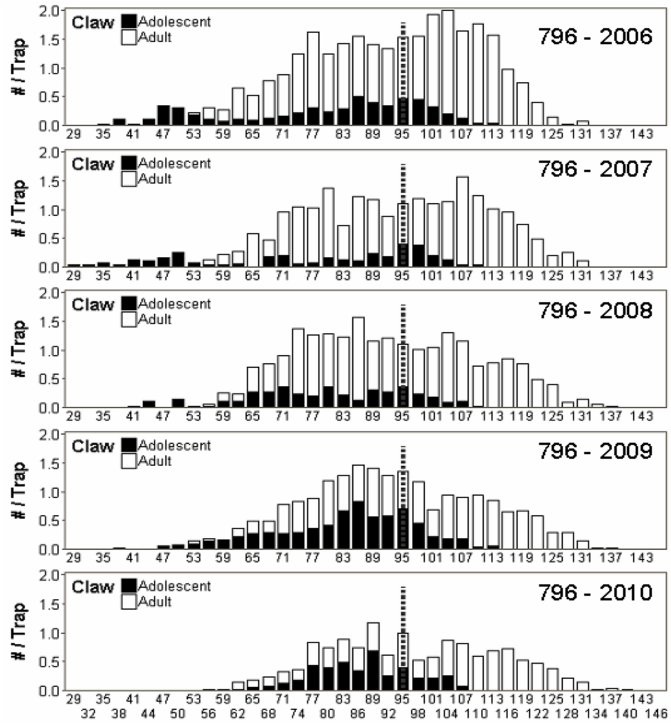


Figure 150: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in the DFO trap survey in Bonavista Bay from 2006-2010.

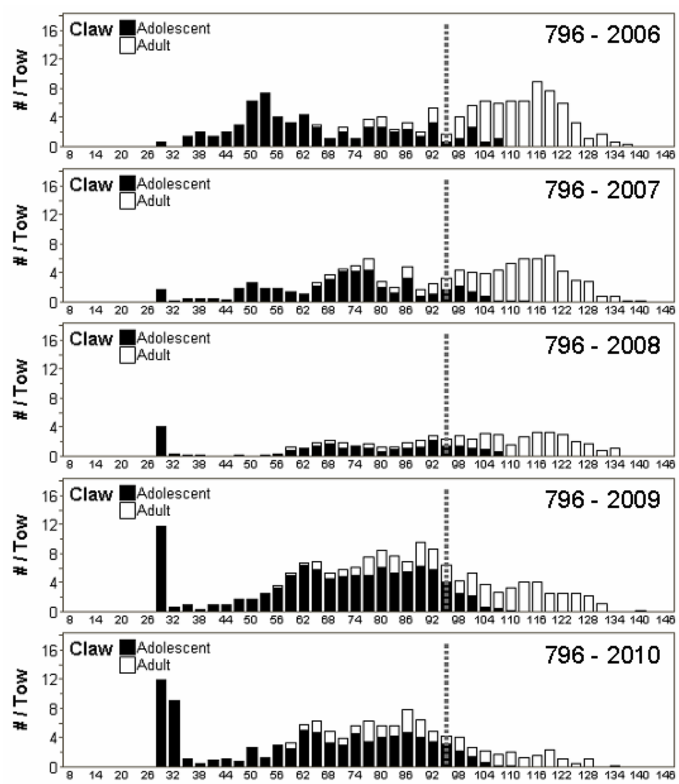


Figure 151: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from the DFO trawl survey in Bonavista Bay from 2006-2010.

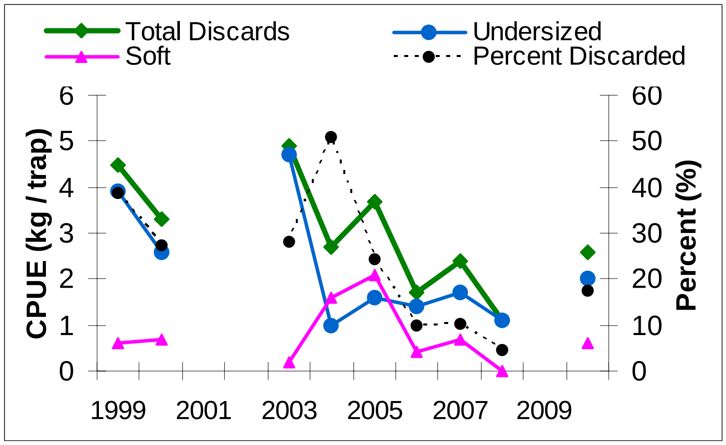


Figure 152: Trends in CMA 5A observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

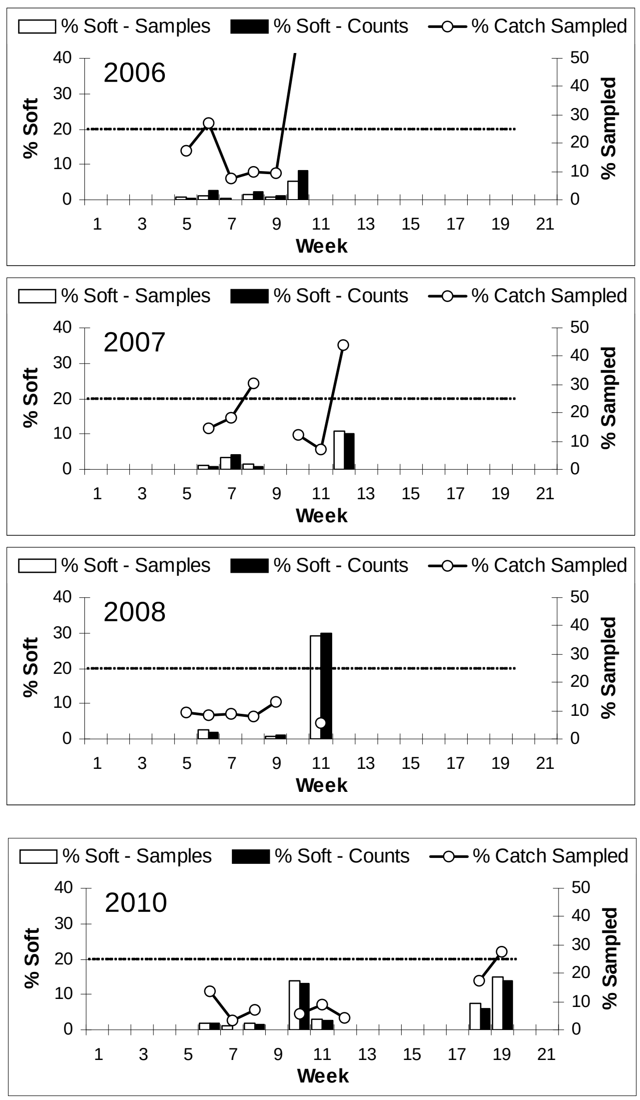


Figure 153: Trends in weekly percentages of soft-shell crab monitored and sampled in CMA 5A from 2006-2010.

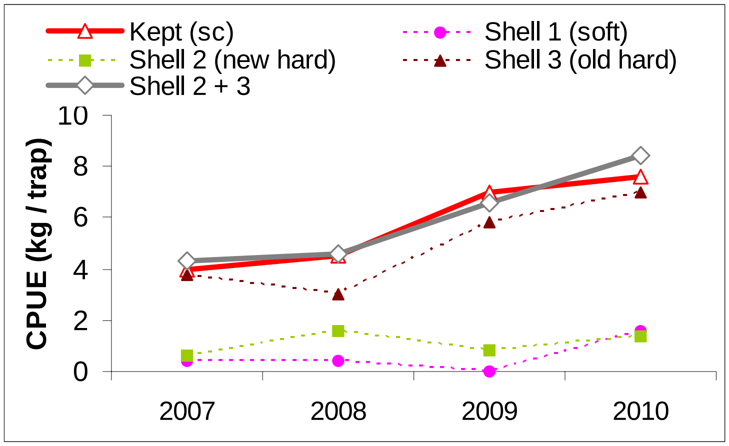


Figure 154: Trends in CMA 6A observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

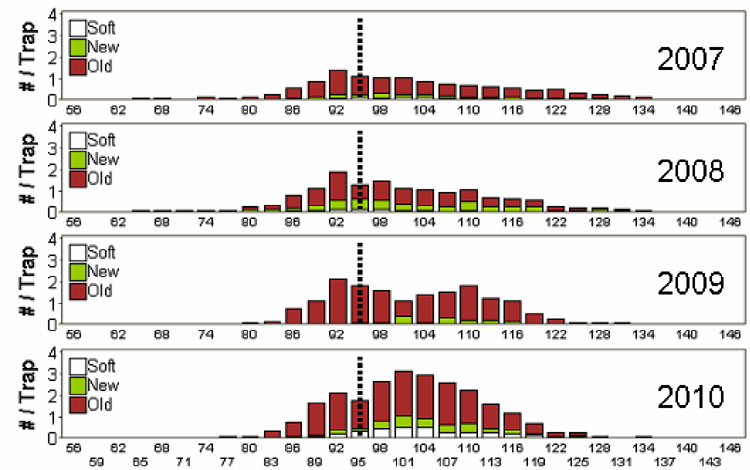


Figure 155: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 5A. The vertical dashed line indicates the minimum legal size.

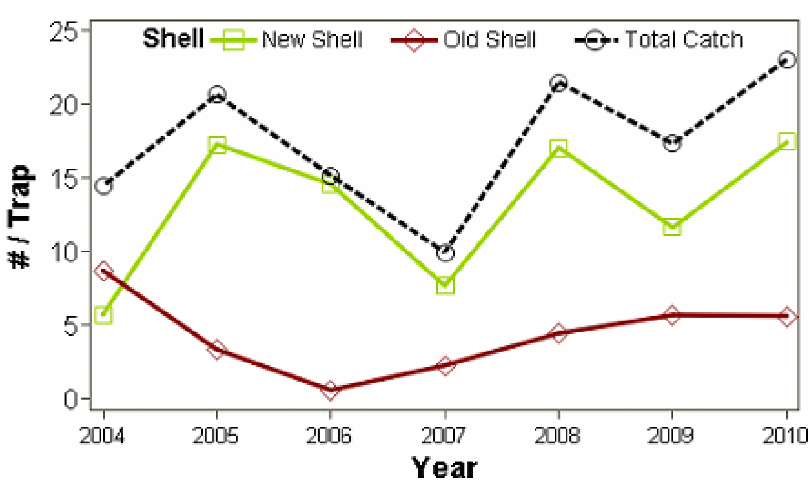


Figure 156: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 6A.

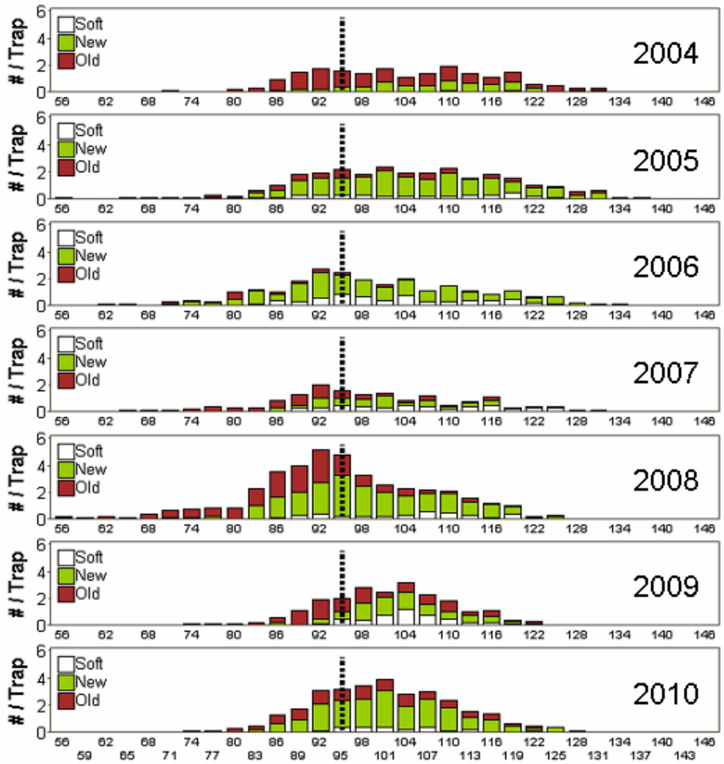


Figure 157: *Trends in male carapace width distributions from core stations in CMA 6A from the CPS trap survey. The vertical dashed line indicates the minimum legal size.*

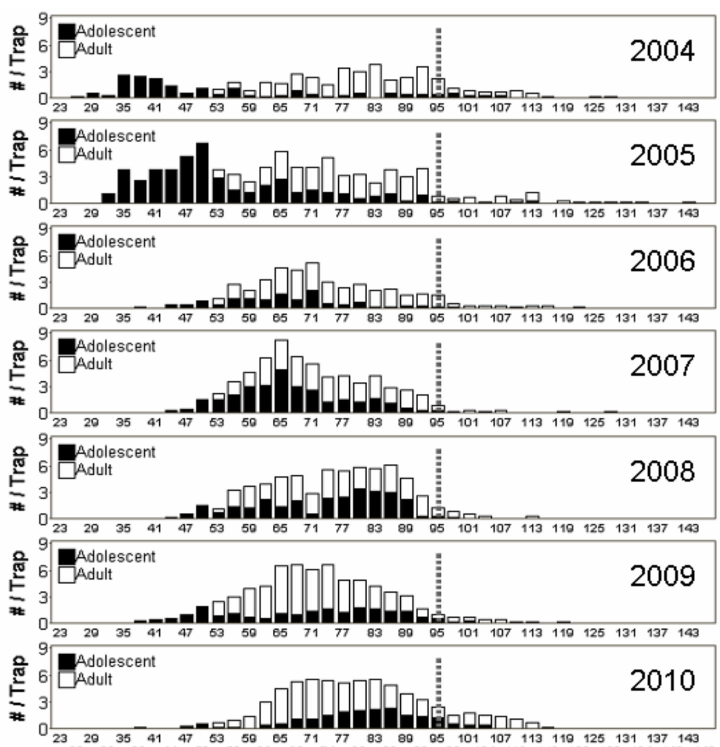


Figure 158: *Trends in male carapace width distributions from small-mesh traps in CMA 6A from the CPS trap survey. The vertical dashed line indicates the minimum legal size.*

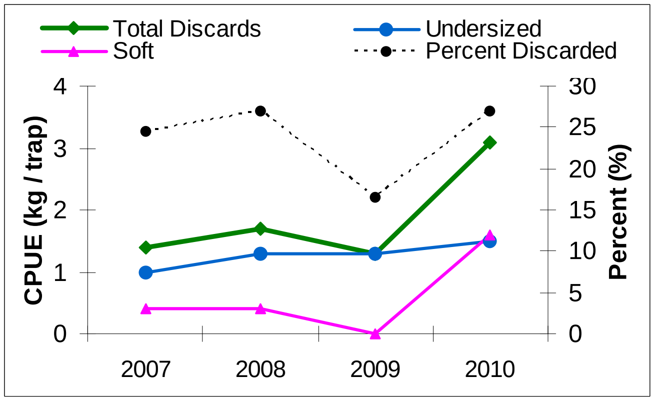


Figure 159: Trends in CMA 5A observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

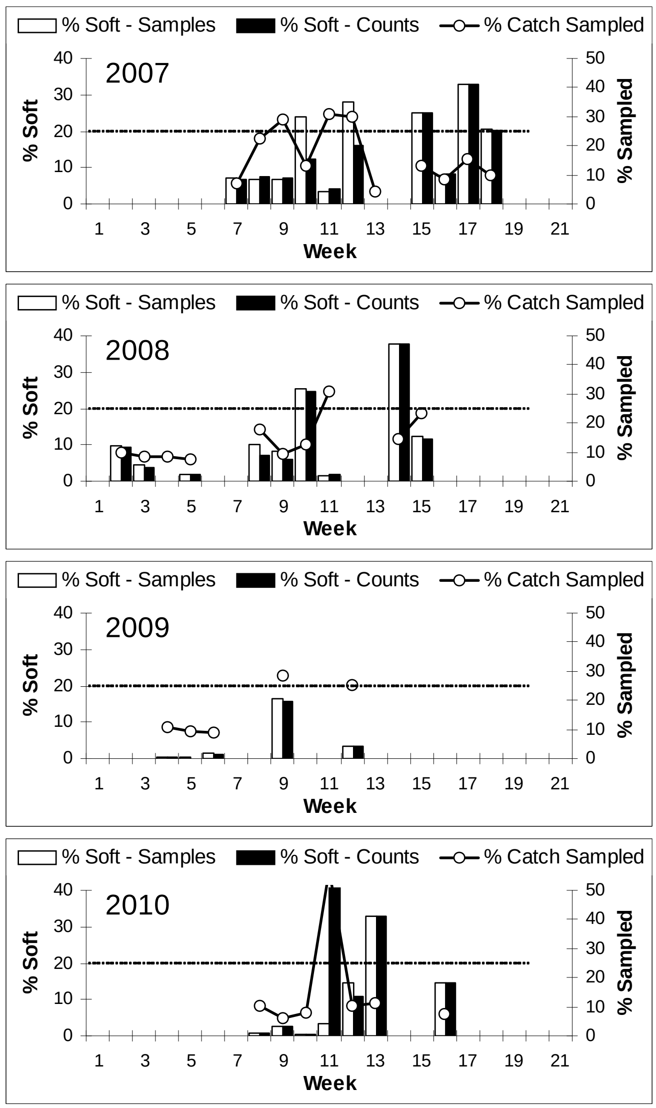


Figure 160: Trends in weekly percentages of soft-shell crab monitored and sampled in CMA 5A from 2006-2010.

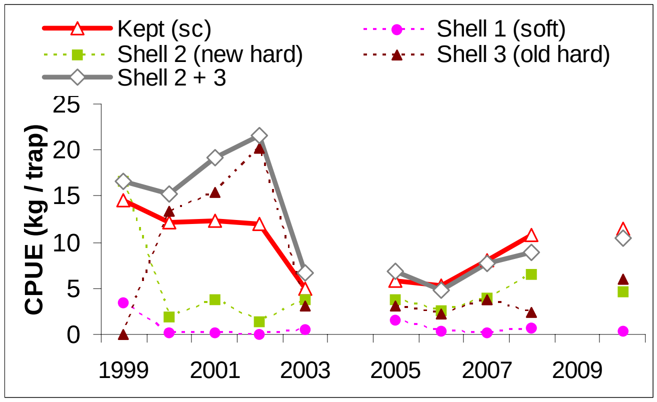


Figure 161: Trends in CMA 6B observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

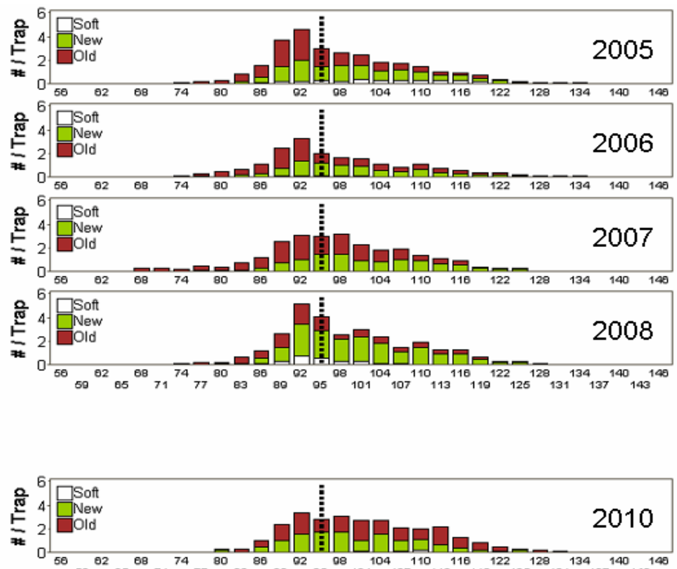


Figure 162: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 6B. The vertical dashed line indicates the minimum legal size.

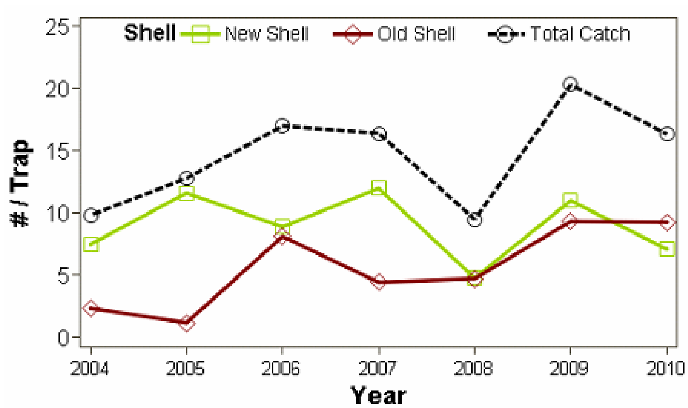


Figure 163: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 6B.

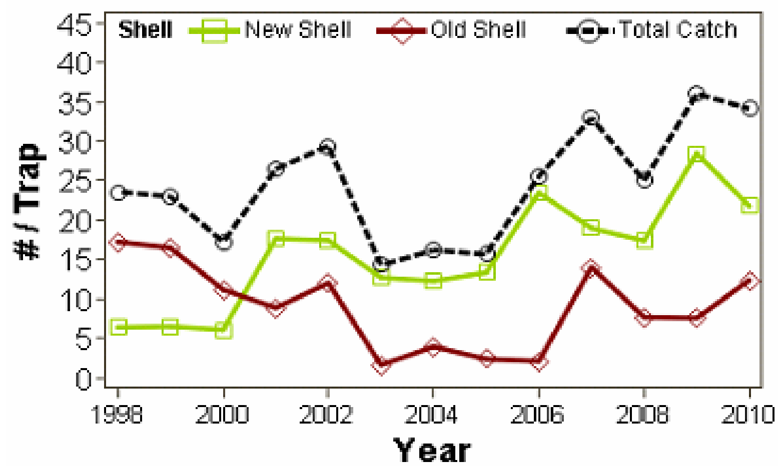


Figure 164: Trends in CPUE by shell condition for legal-sized crabs from the stratum occupied in the DFO trap survey in Conception Bay.

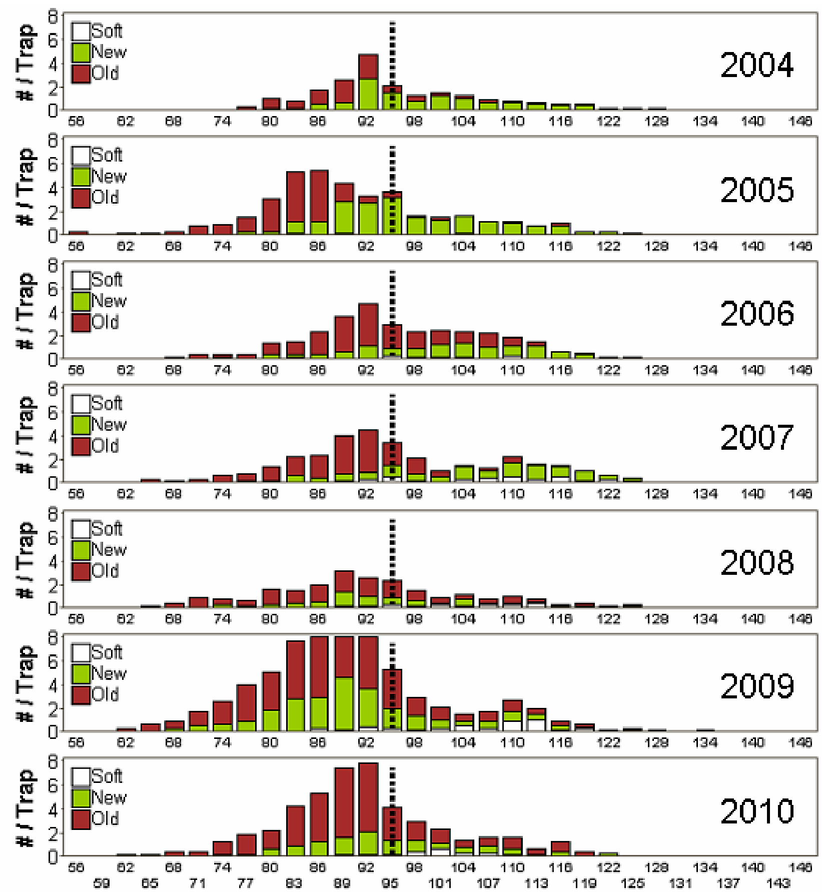


Figure 165: Trends in male carapace width distributions from core stations in CMA 6B from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

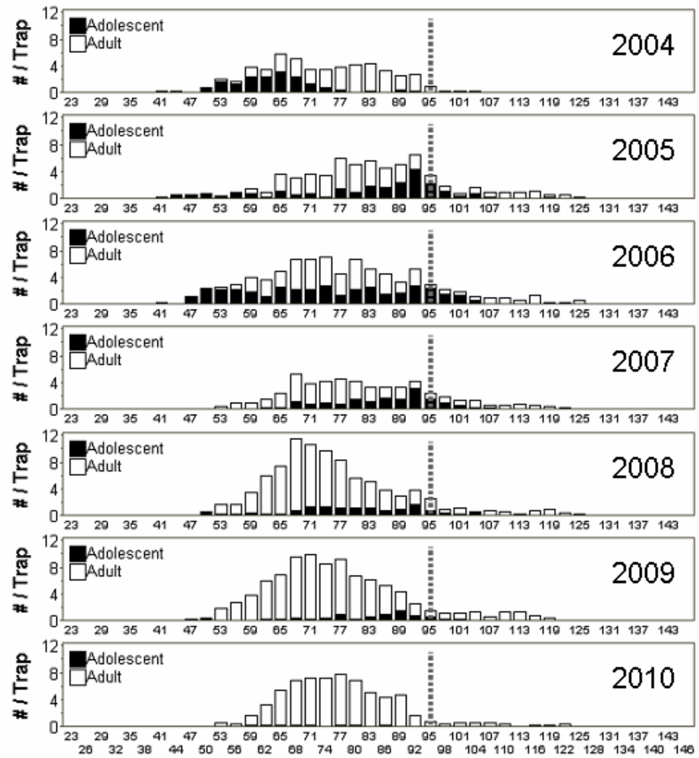


Figure 166: Trends in male carapace width distributions from small-mesh traps in CMA 6B from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

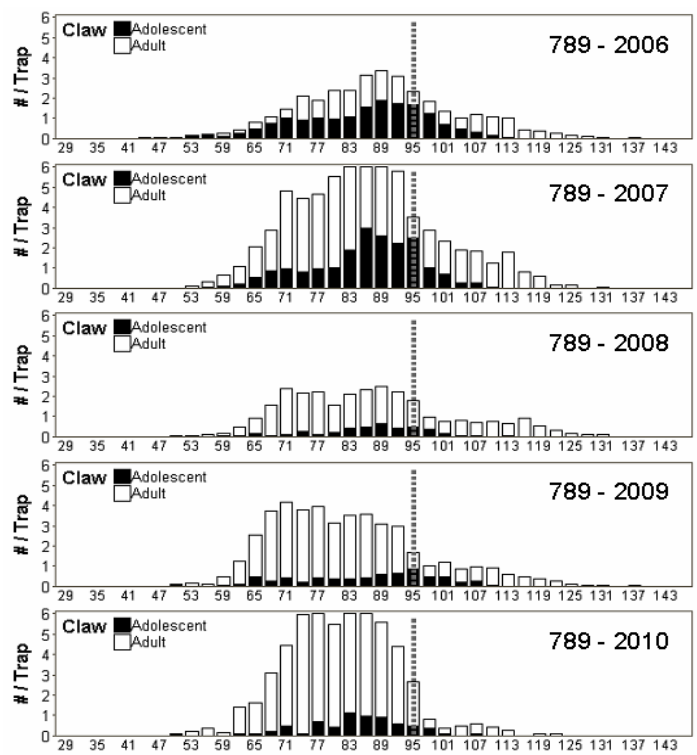


Figure 167: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in the DFO trap survey in Conception Bay from 2006-2010.

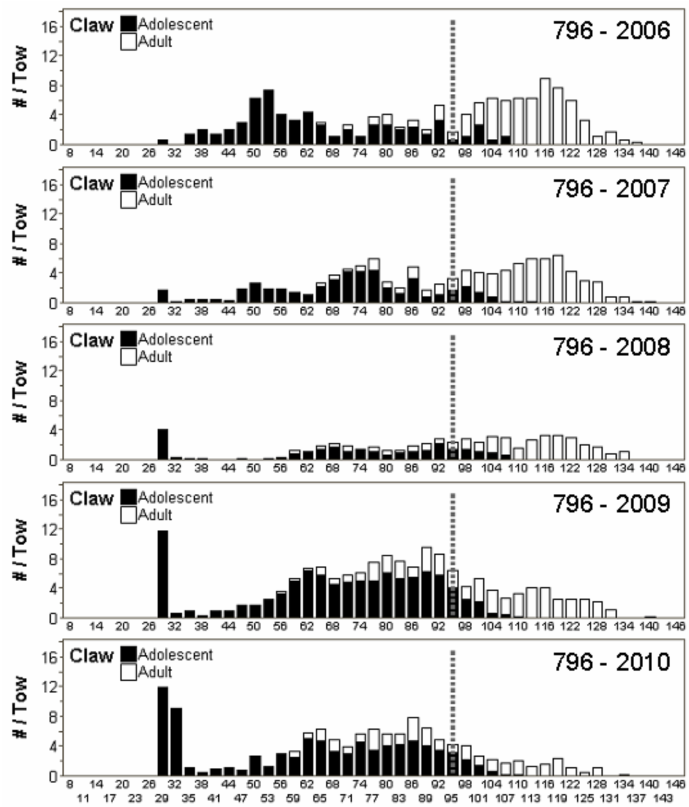


Figure 168: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from the DFO trawl survey in Conception Bay from 2006-2010.

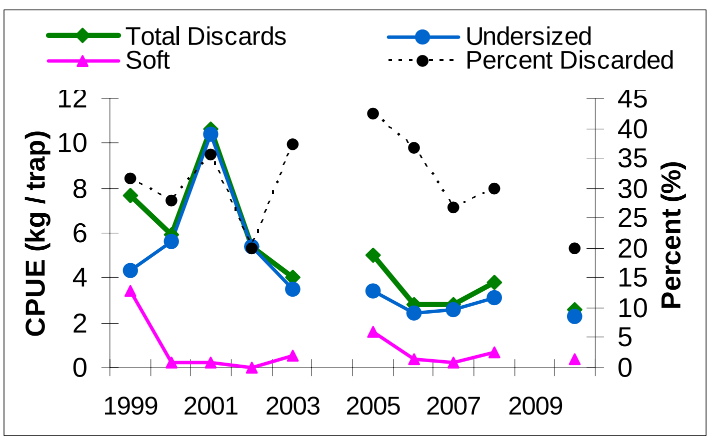


Figure 169: Trends in CMA 6B observer catch rates of total discards, undersized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

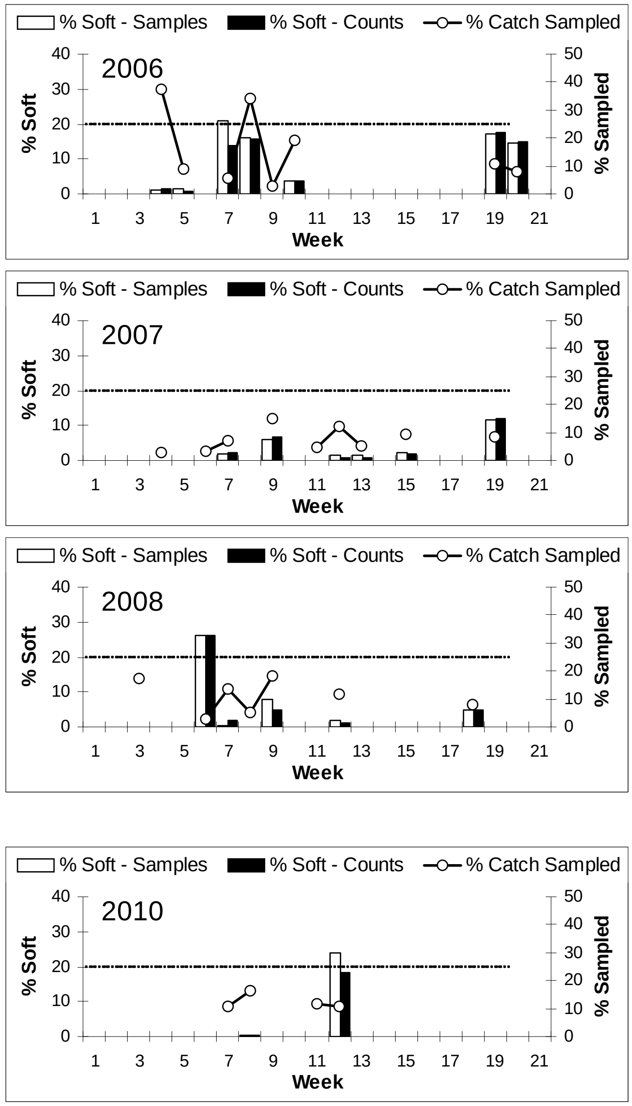


Figure 170: Trends in weekly percentages of soft-shell crab monitored and sampled in CMA 6B from 2006-2010.

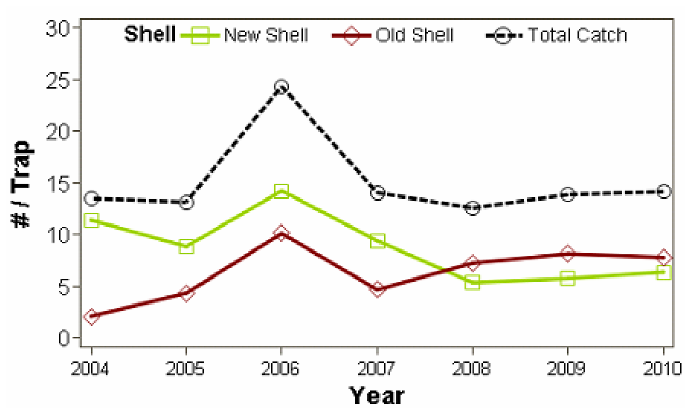


Figure 171: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 6C.

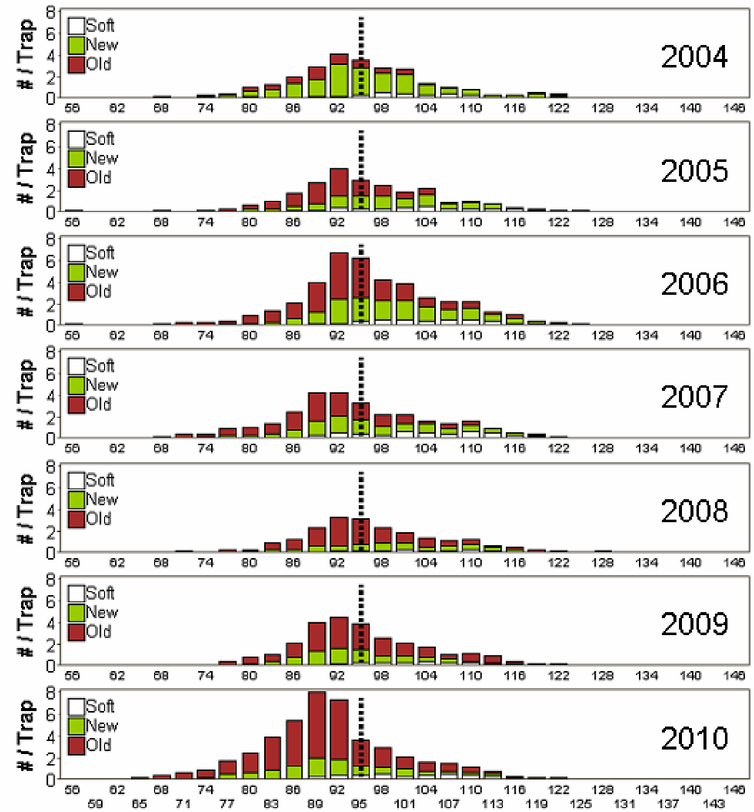


Figure 172: Trends in male carapace width distributions from core stations in CMA 6C from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

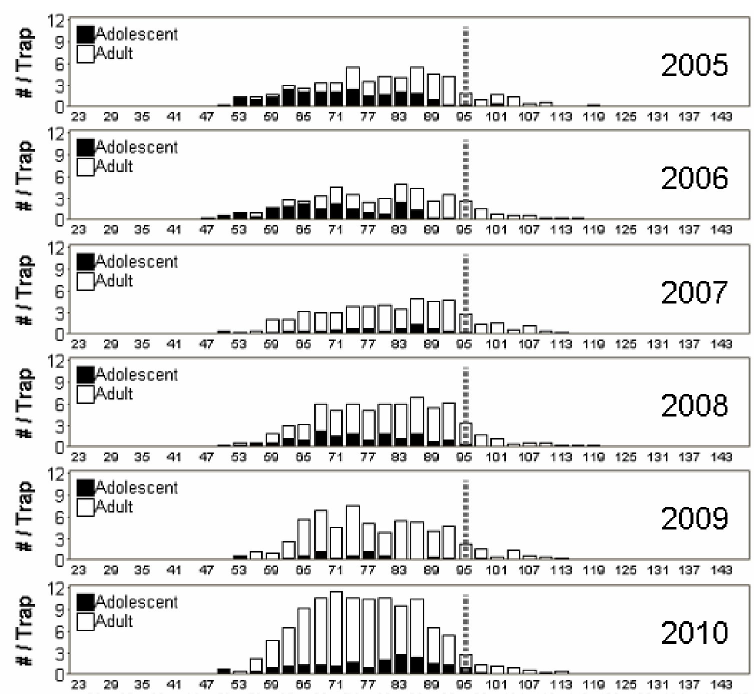


Figure 173: Trends in male carapace width distributions from small-mesh traps in CMA 6C from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

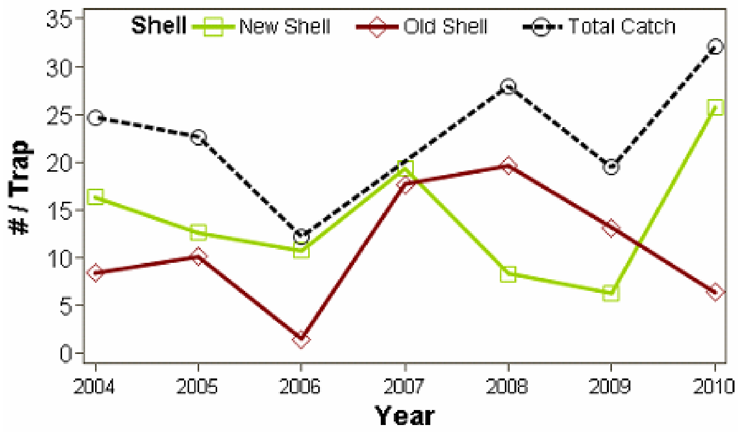


Figure 174: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 8A

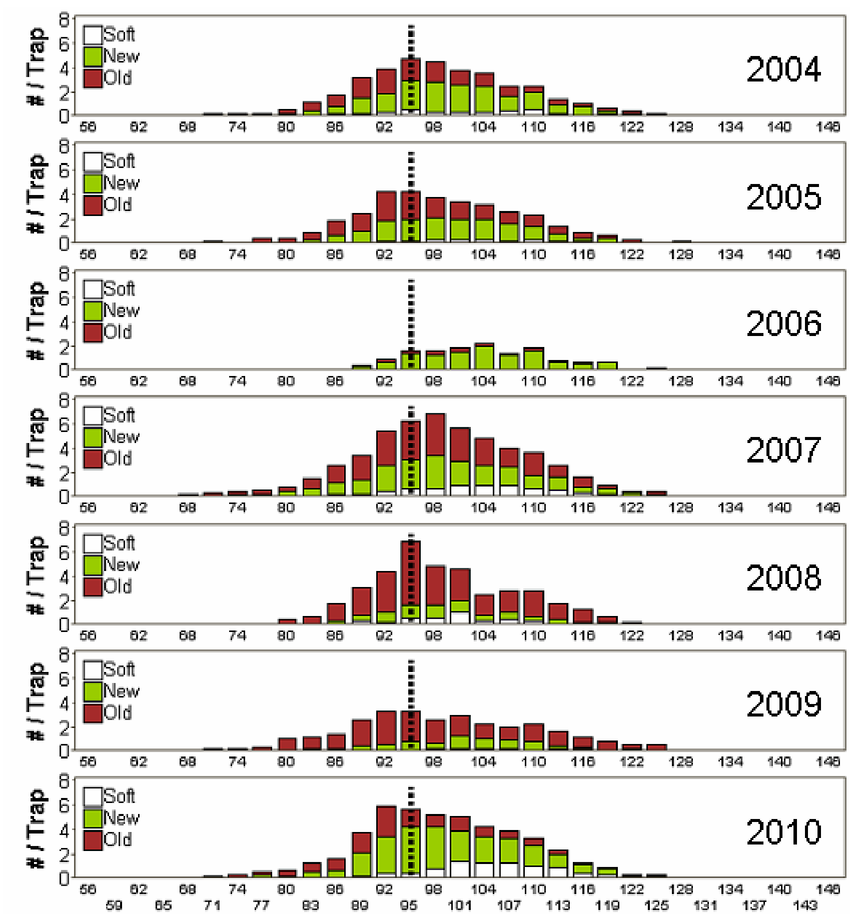


Figure 175: Trends in male carapace width distributions from core stations in CMA 8A in the CPS trap survey. The vertical dashed line indicates the minimum legal size.

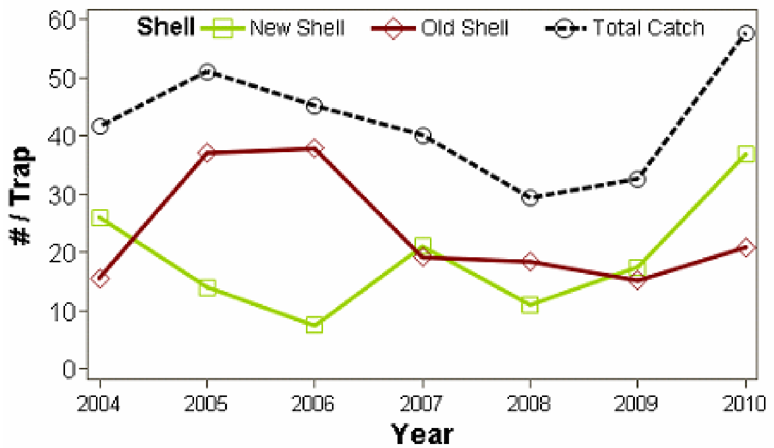


Figure 176: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 9A.

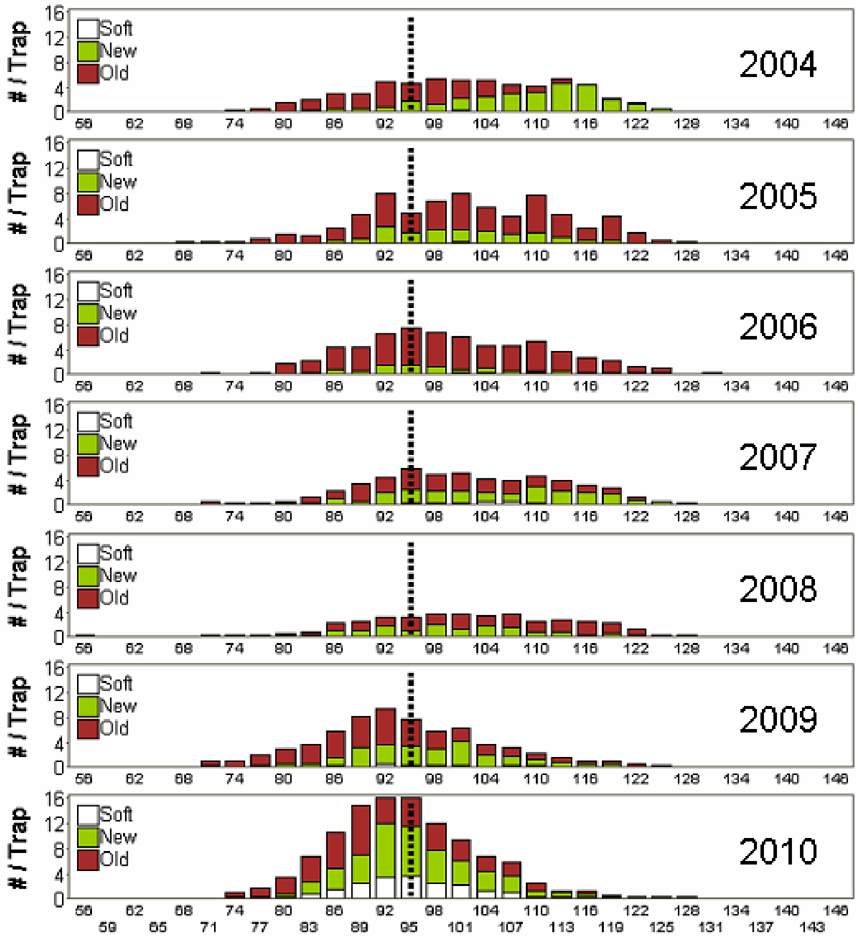


Figure 177: Trends in male carapace width distributions from core stations in CMA 9A in the CPS trap survey. The vertical dashed line indicates the minimum legal size.

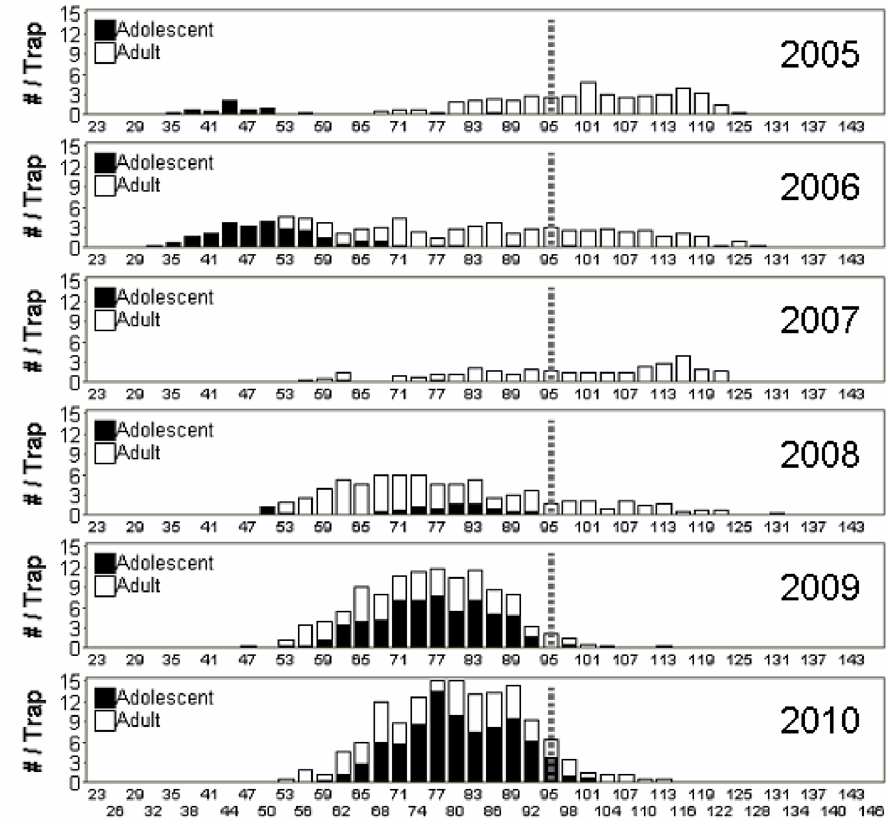


Figure 178: Trends in male carapace width distributions from small-mesh traps in CMA 9A from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

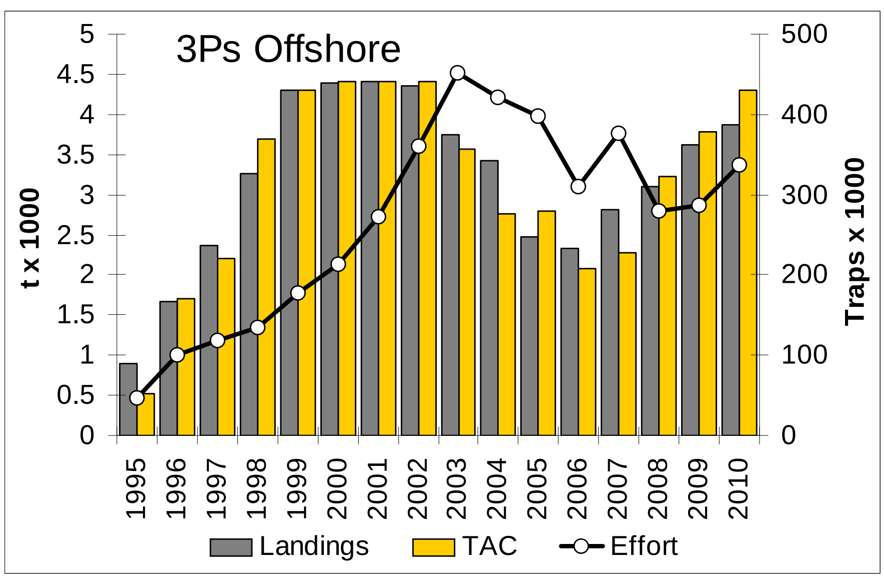


Figure 179: Trends in Subdiv. 3Ps offshore landings, TAC, and fishing effort.

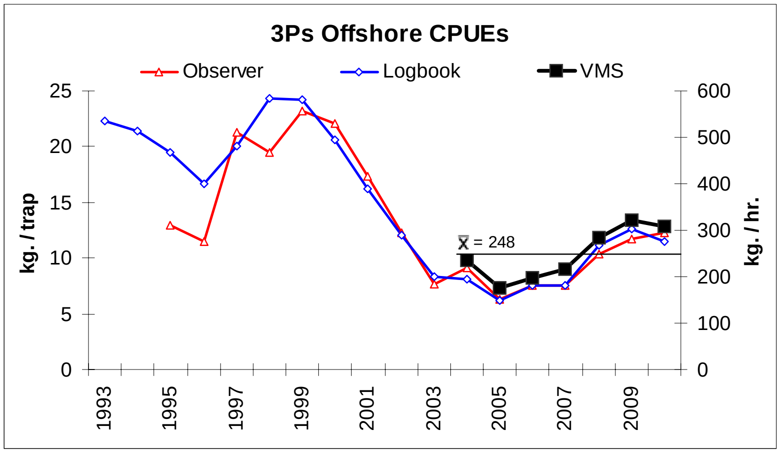


Figure 180: Trends in commercial logbook-based, observer-based, and VMS-based CPUE in the Subdiv. 3Ps offshore fishery. Solid black line denotes long-term VMS average.

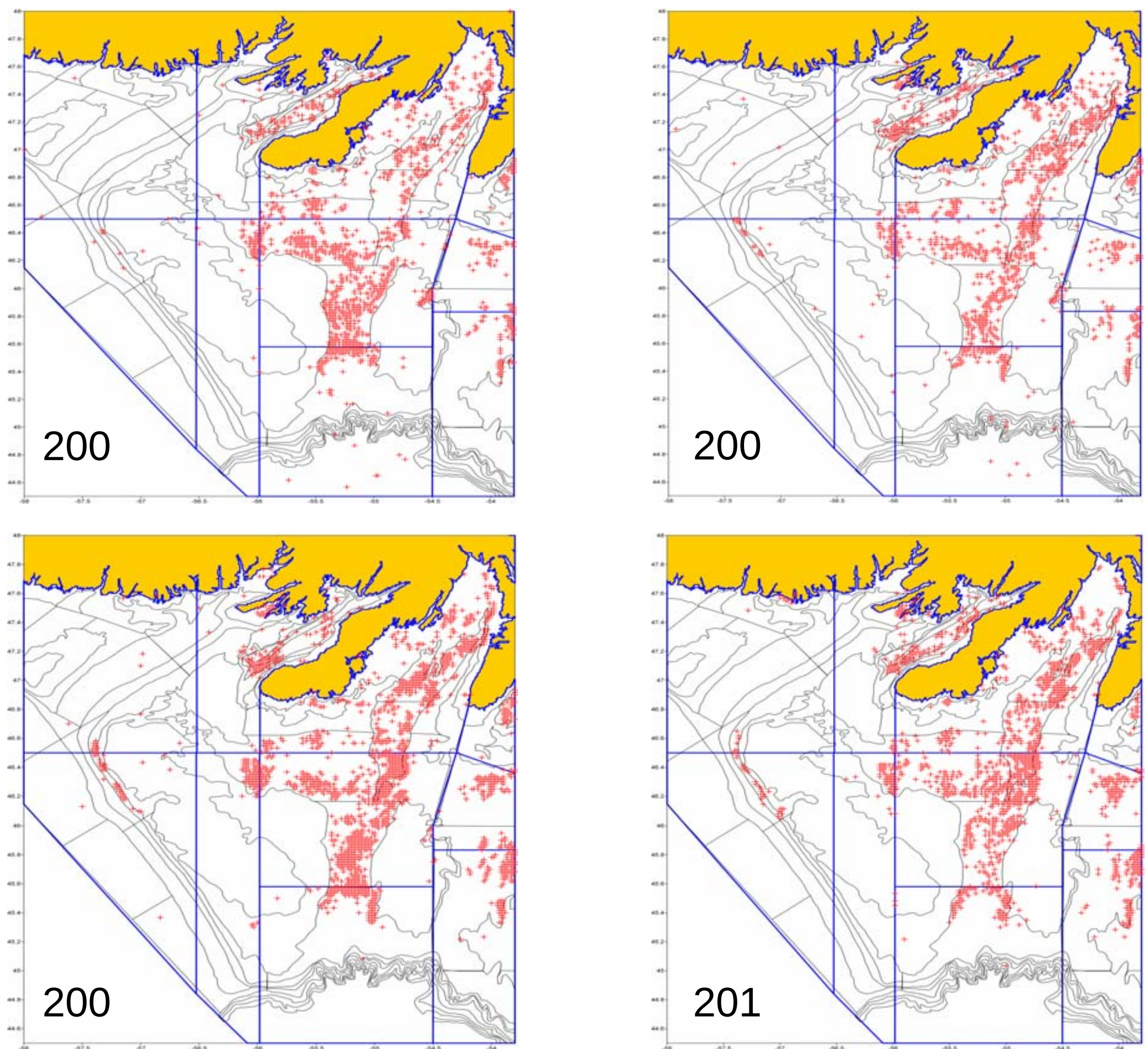


Figure 181: Spatial distribution of Subdiv. 3Ps fishing effort by year.

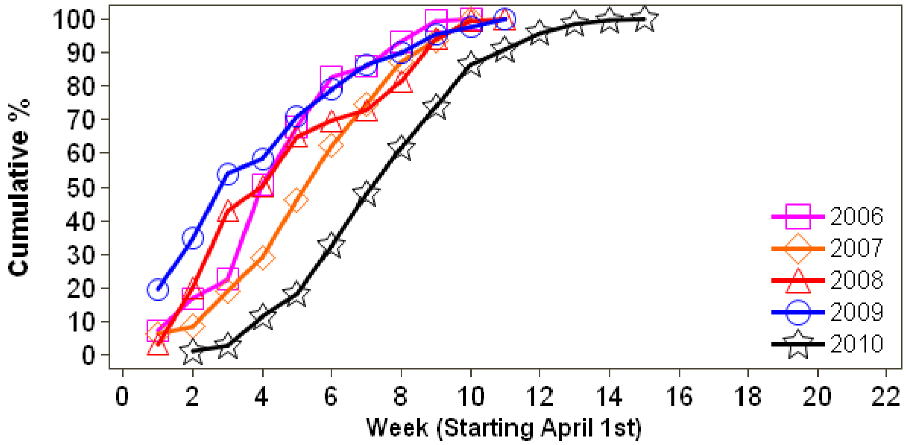


Figure 182: Seasonal trends in fishing effort for Subdiv. 3Ps offshore during 2006-2010.

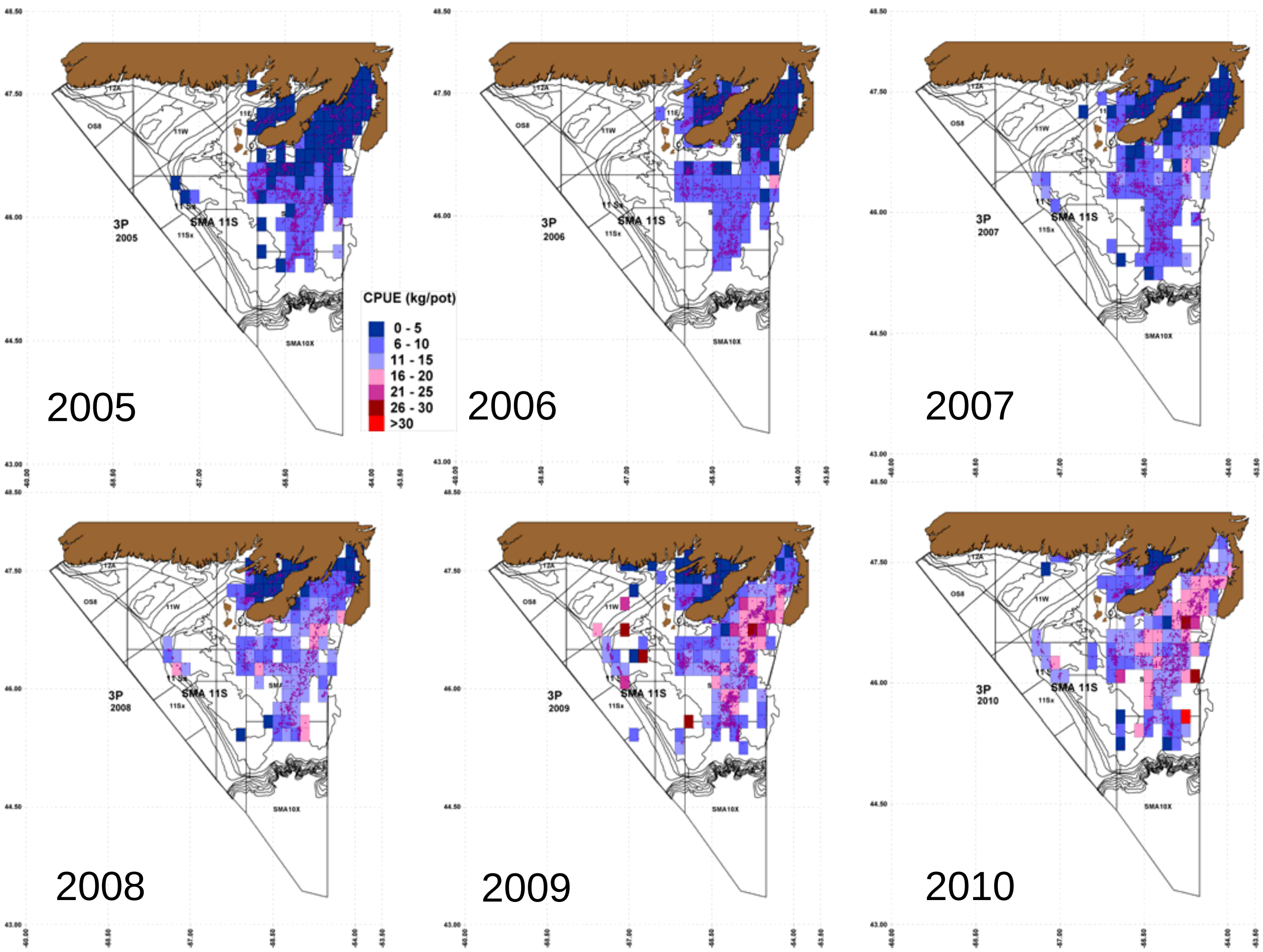


Figure 183: Spatial distribution of Subdiv. 3Ps logbook CPUE by year.

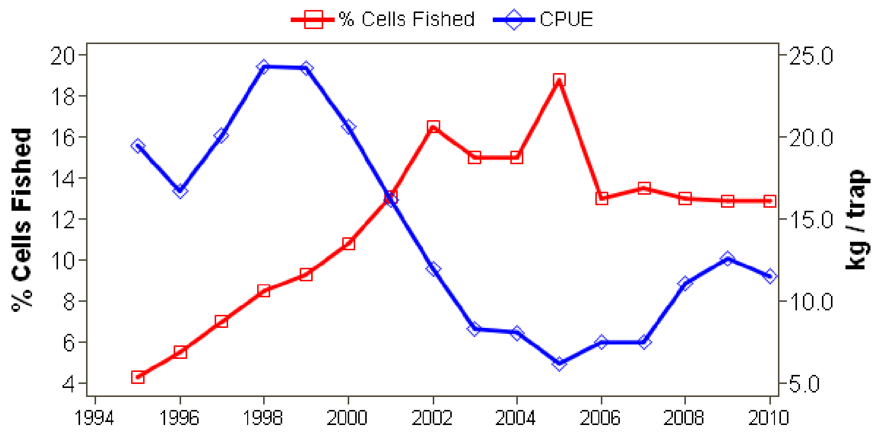


Figure 184: Trends in Subdiv. 3Ps offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

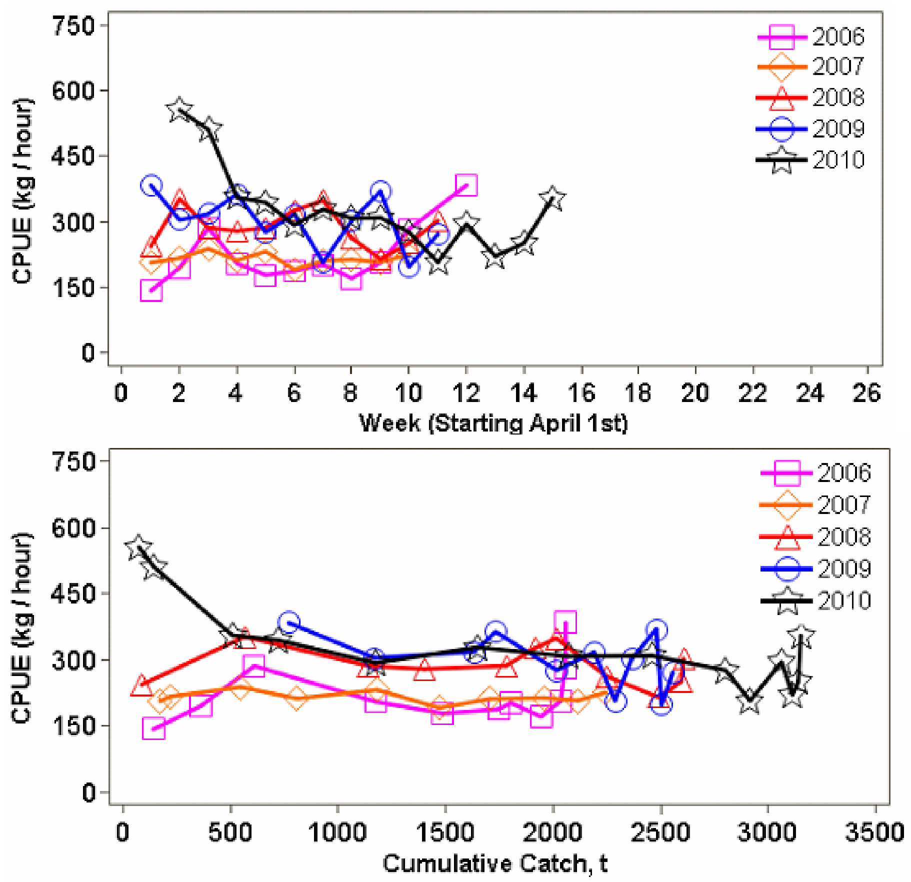


Figure 185: Seasonal trends in VMS-based CPUE for Subdiv. 3Ps offshore during 2006-2010; (above) by week, and (below) in relation to cumulative catch.

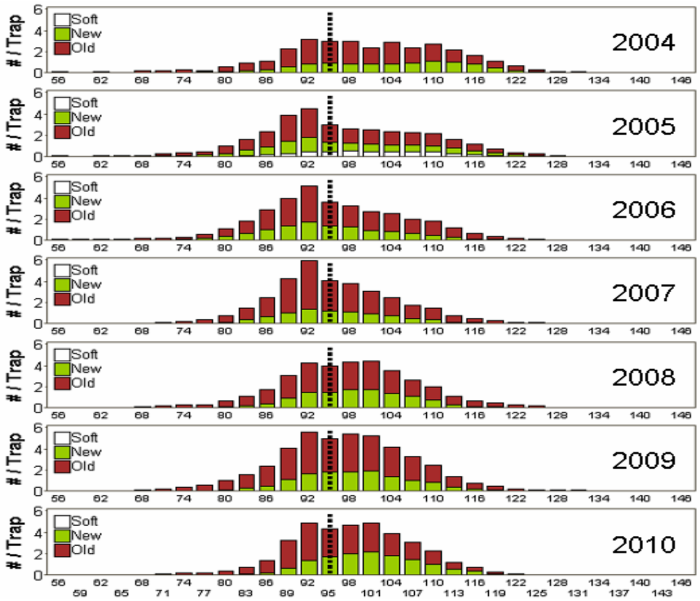


Figure 186: Trends in male carapace width distributions by shell condition from observer at-sea sampling for Subdiv. 3Ps offshore. The vertical dashed line indicates the minimum legal size.

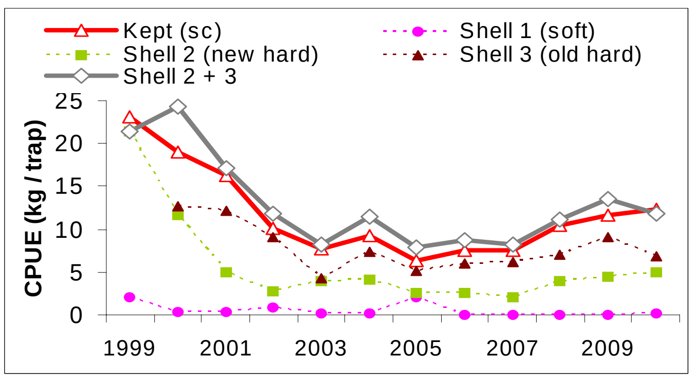


Figure 187: Trends in Subdiv. 3Ps offshore observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

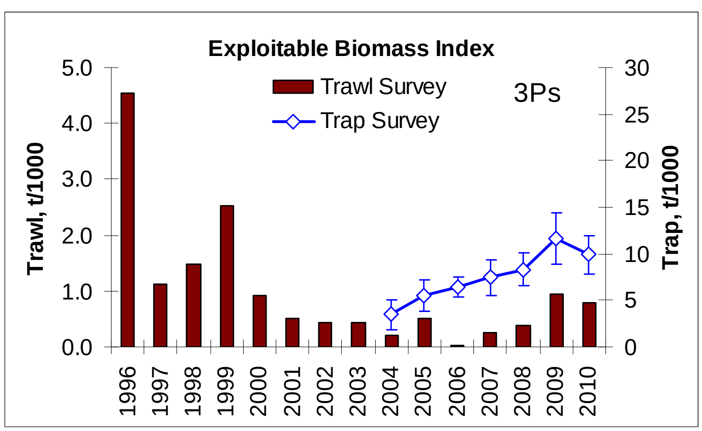


Figure 188: Trends in the Subdiv. 3Ps offshore spring trawl survey exploitable biomass index and the CPS trap survey biomass index. The trawl survey was incomplete in 2006.

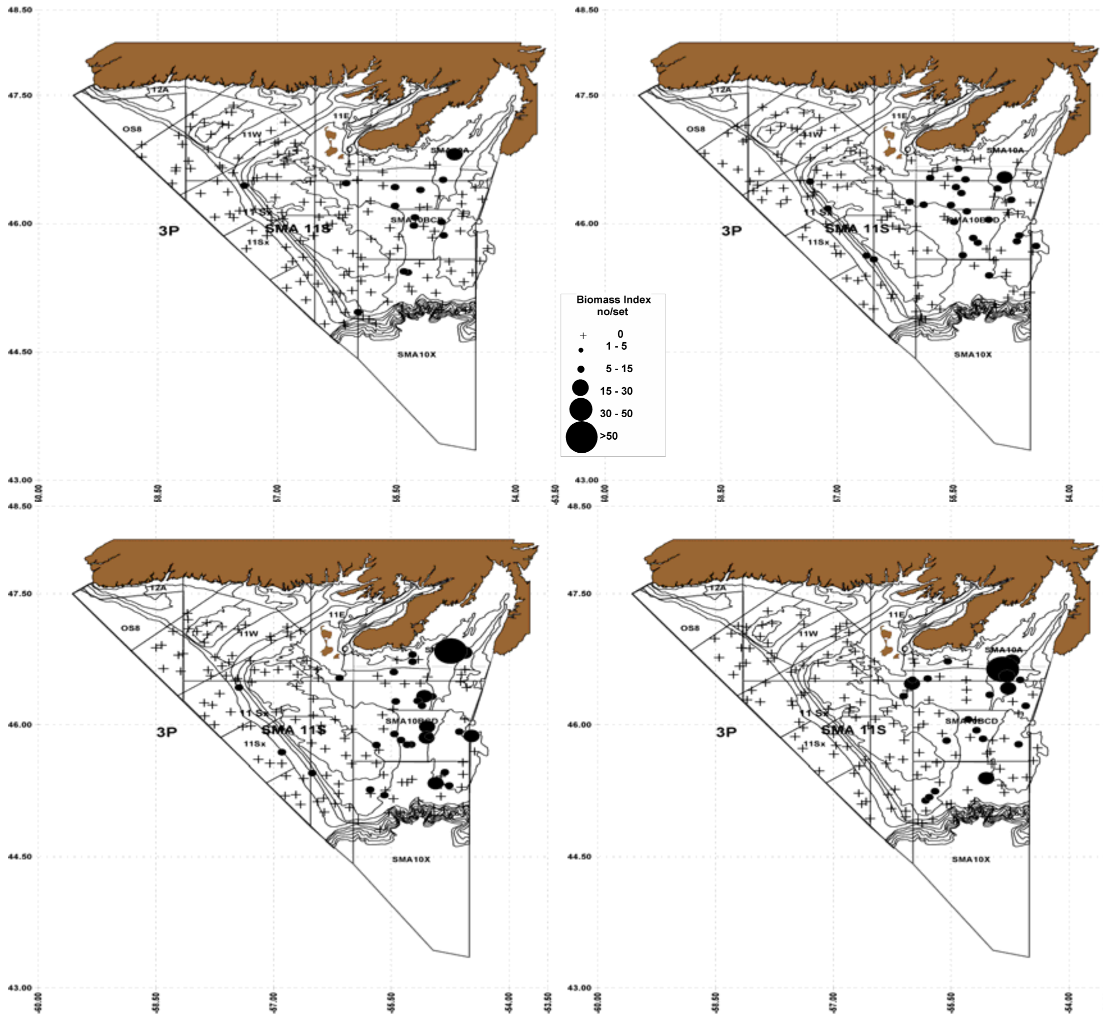


Figure 189: Spatial distribution of catches (number/set) of exploitable crab in the Subdiv. 3Ps offshore trawl survey.

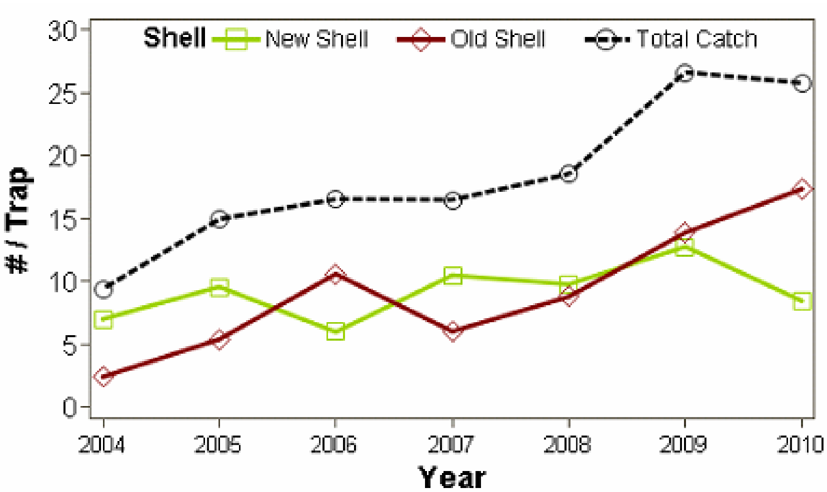


Figure 190: Trends in CPUE by shell condition for legal-sized crabs from core stations in the Subdiv. 3Ps offshore CPS trap survey.

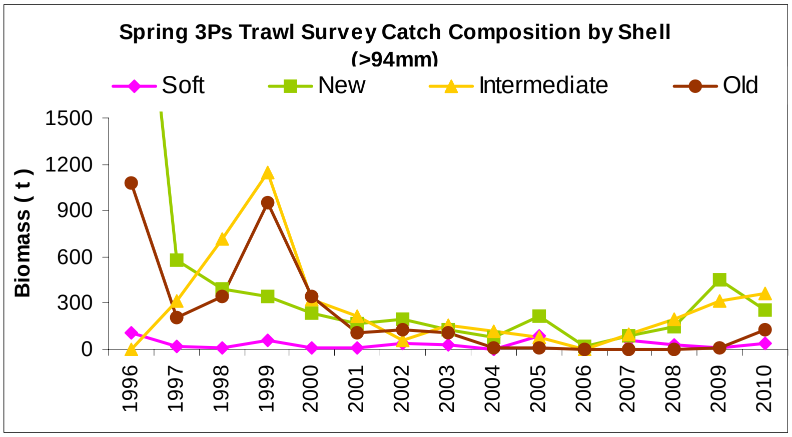


Figure 191: Trends, by shell condition, in legal-sized males for Subdiv. 3Ps offshore from spring trawl surveys.

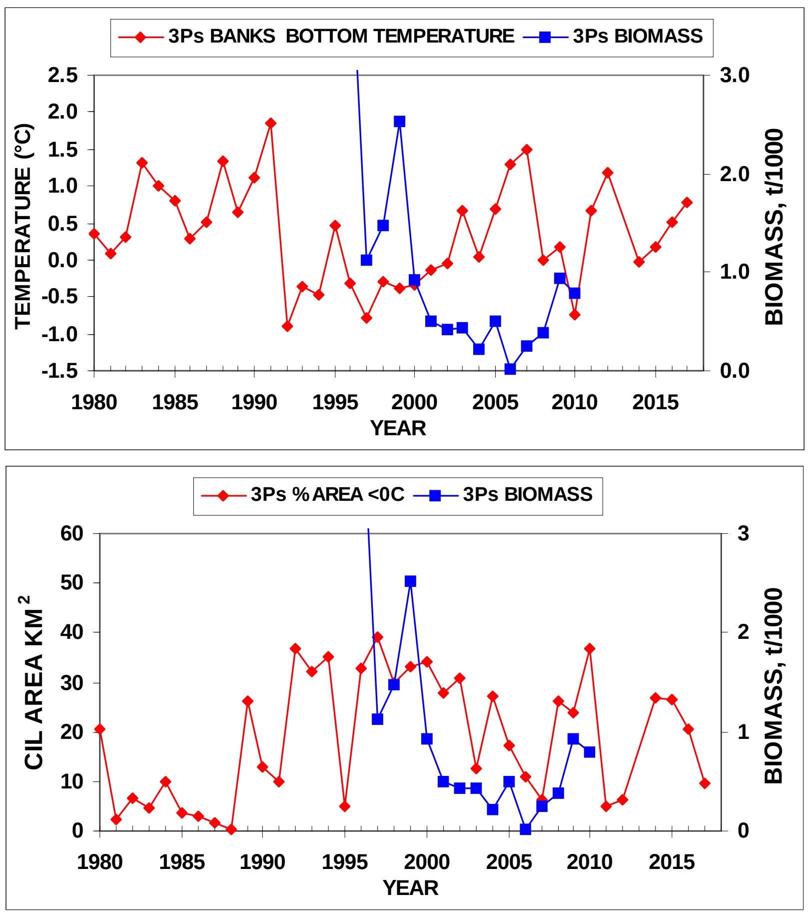


Figure 192: Trends in the Subdiv. 3Ps offshore exploitable biomass index vs. bottom temperature at a seven year lag (above) and vs. the spatial extent of the cold intermediate layer at a seven year lag (below).

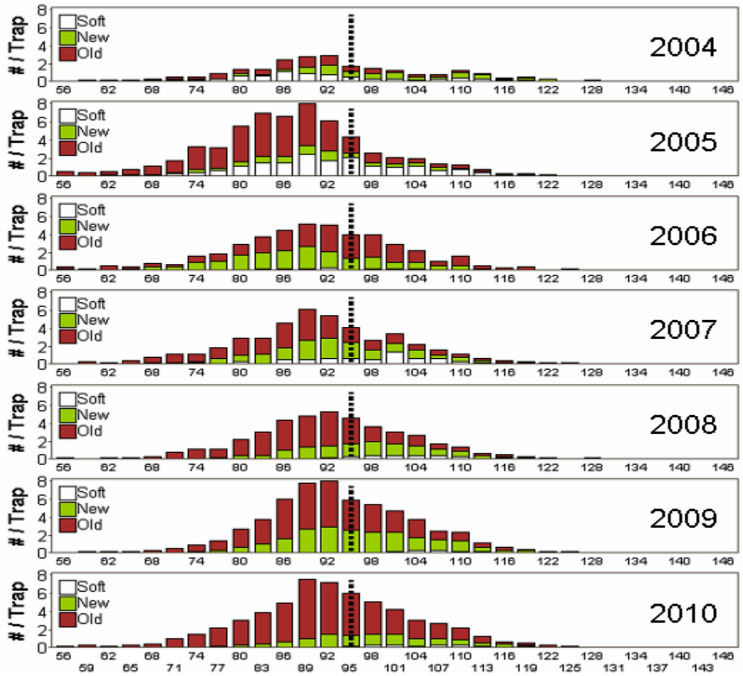


Figure 193: Trends in male carapace width distributions from core stations in the Subdiv. 3Ps offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

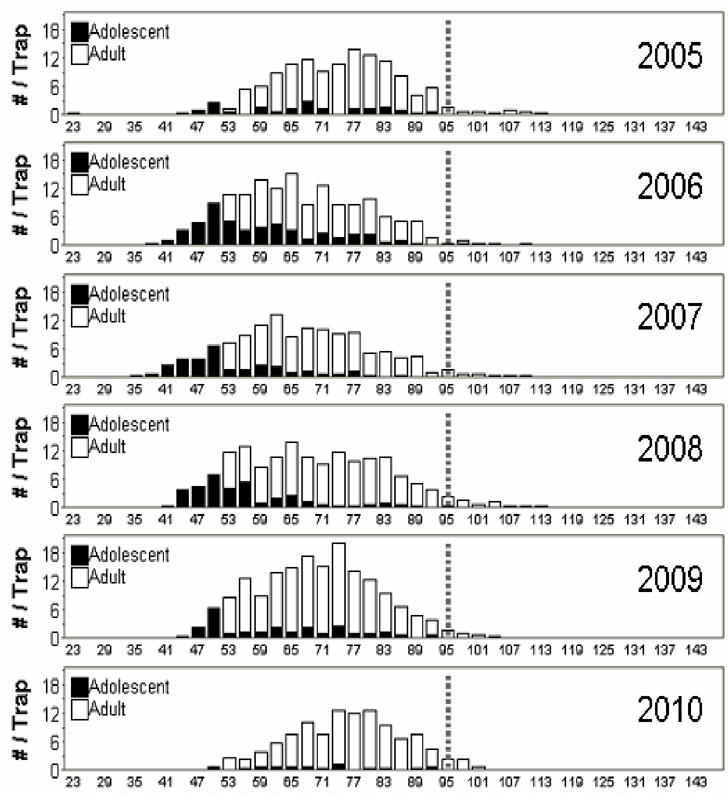


Figure 194: Trends in male carapace width distributions from small-mesh traps in the Subdiv. 3Ps offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

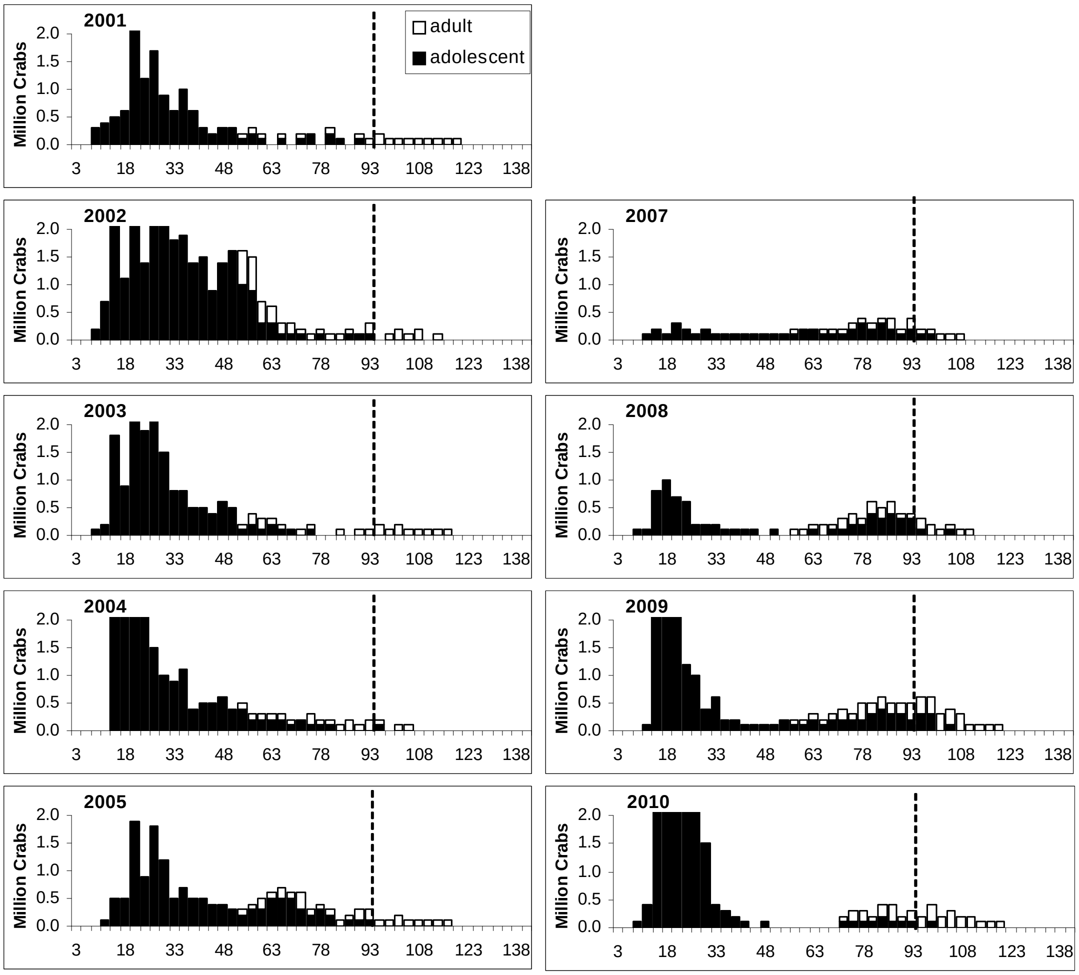


Figure 195: Abundance indices by carapace width for Subdiv. 3Ps juveniles plus adolescents (dark bars) versus adults (open bars) from spring trawl surveys. Abundance is truncated for smallest crabs (< 50mm CW). The minimum legal size is indicated by a vertical dashed line. The survey was incomplete in 2006.

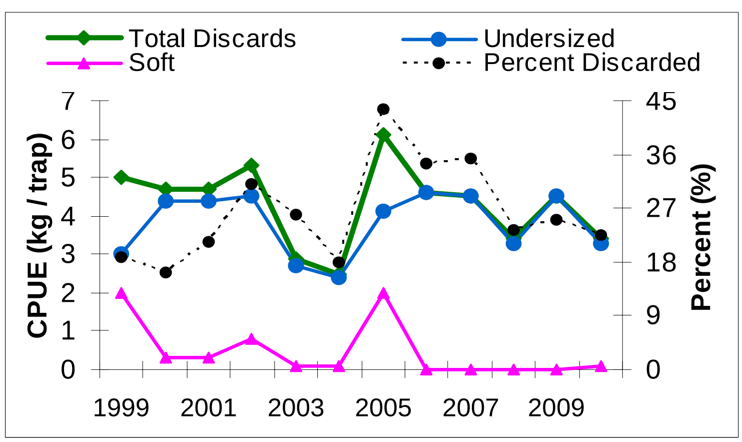


Figure 196: Trends in Subdiv. 3Ps offshore observer catch rates of total discards, under-sized discards, and legal-sized soft-shelled discards, as well as the percentage of the catch discarded.

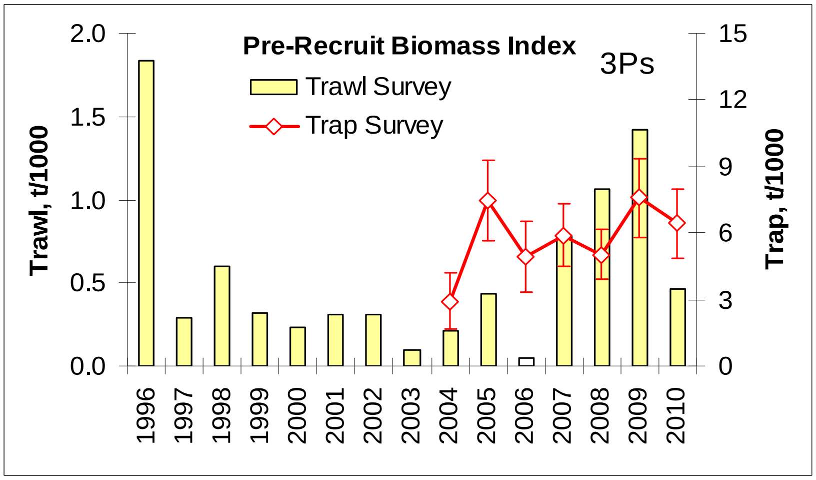


Figure 197: Trends in the Subdiv. 3Ps trawl survey pre-recruit biomass index and the CPS trap survey biomass index. The trawl survey was incomplete in 2006.

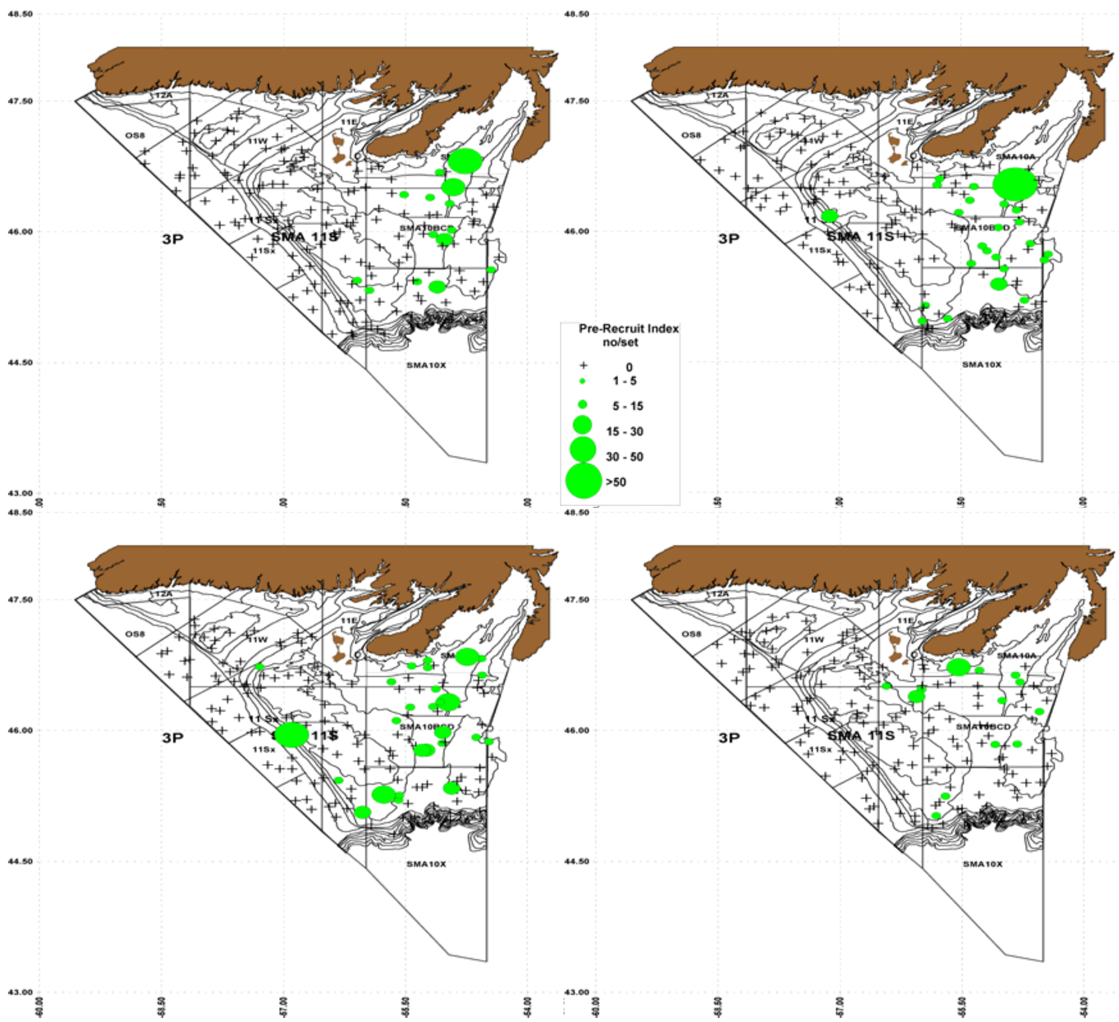


Figure 198: Spatial distribution of catches (number/set) of pre-recruit crab in the Subdiv. 3Ps offshore trawl survey.

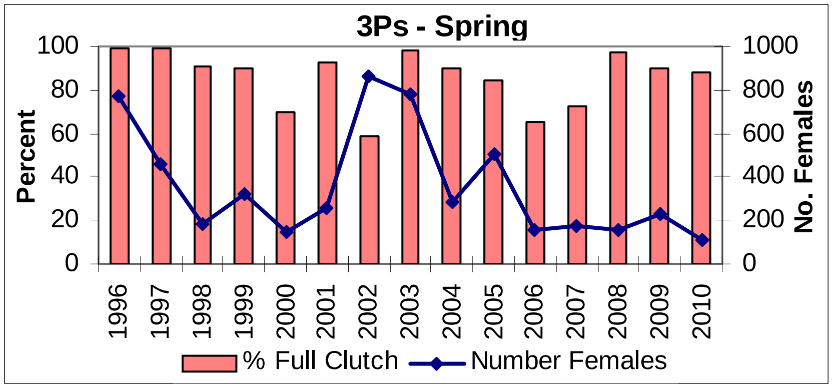


Figure 199: Trends in percent of mature females bearing full clutches of viable eggs and samples sizes in Subdiv. 3Ps from fall multi-species surveys.

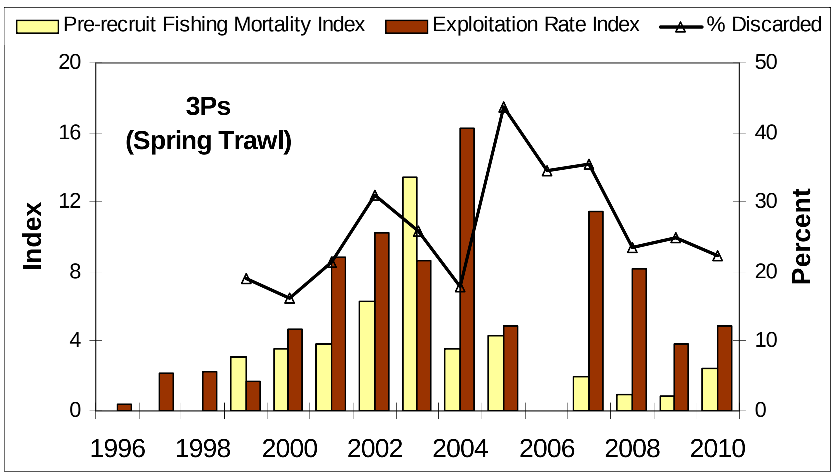


Figure 200: Trends in Subdiv. 3Ps offshore mortality indices (the exploitation rate index and the pre-recruit fishing mortality index) and in the percentage of the catch discarded in the fishery. (No 2006 exploitation rate or pre-recruit fishing mortality indices because of an incomplete 2006 survey).

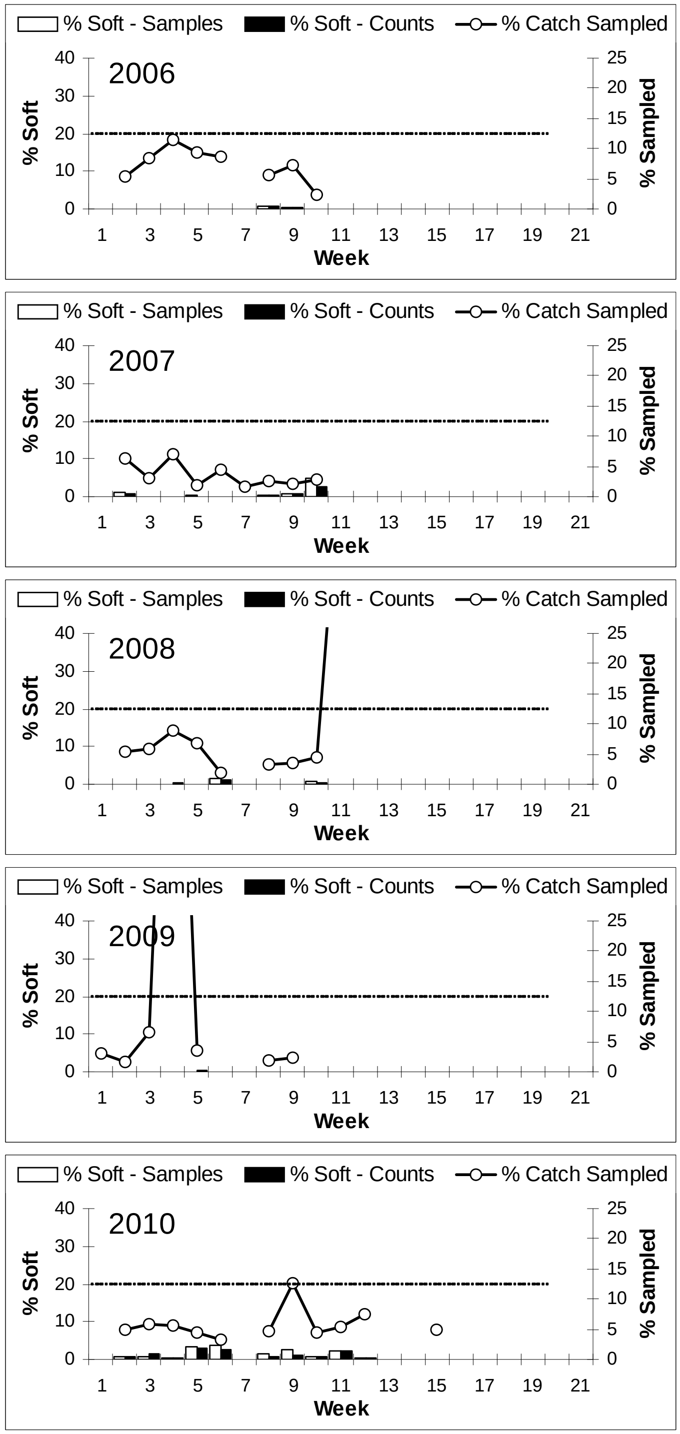


Figure 201: Trends in weekly percentages of soft-shell crab monitored and sampled in Subdiv. 3Ps Offshore from 2006-2010.

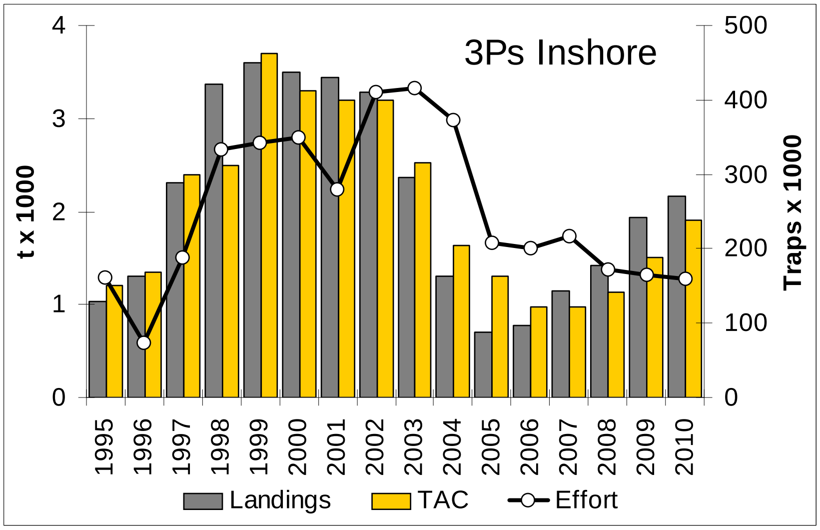


Figure 202: Trends in Subdiv. 3Ps inshore landings, TAC, and fishing effort.

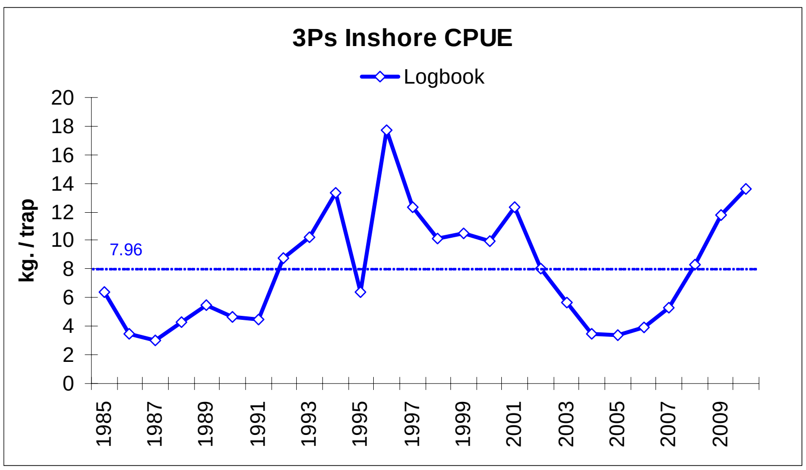


Figure 203: Trends in commercial logbook-based CPUE in the Subdiv. 3Ps inshore fishery.

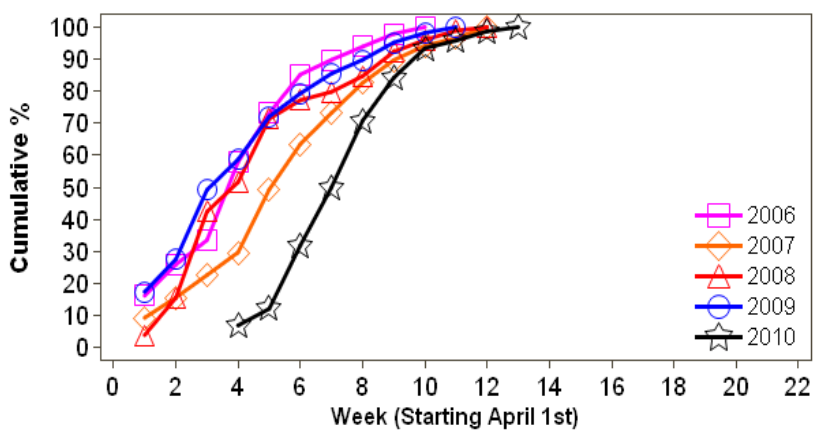


Figure 204: Seasonal trends in weekly fishing effort for Subdiv. 3Ps inshore during 2006-2010.

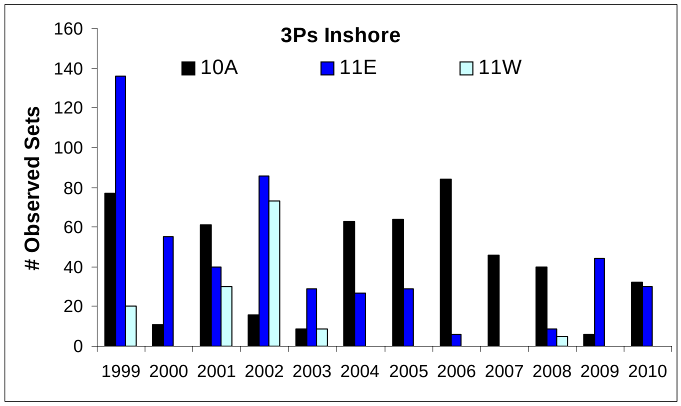


Figure 205: Trends in number of observed sets by Crab Management Areas and year in Subdivision 3Ps inshore.

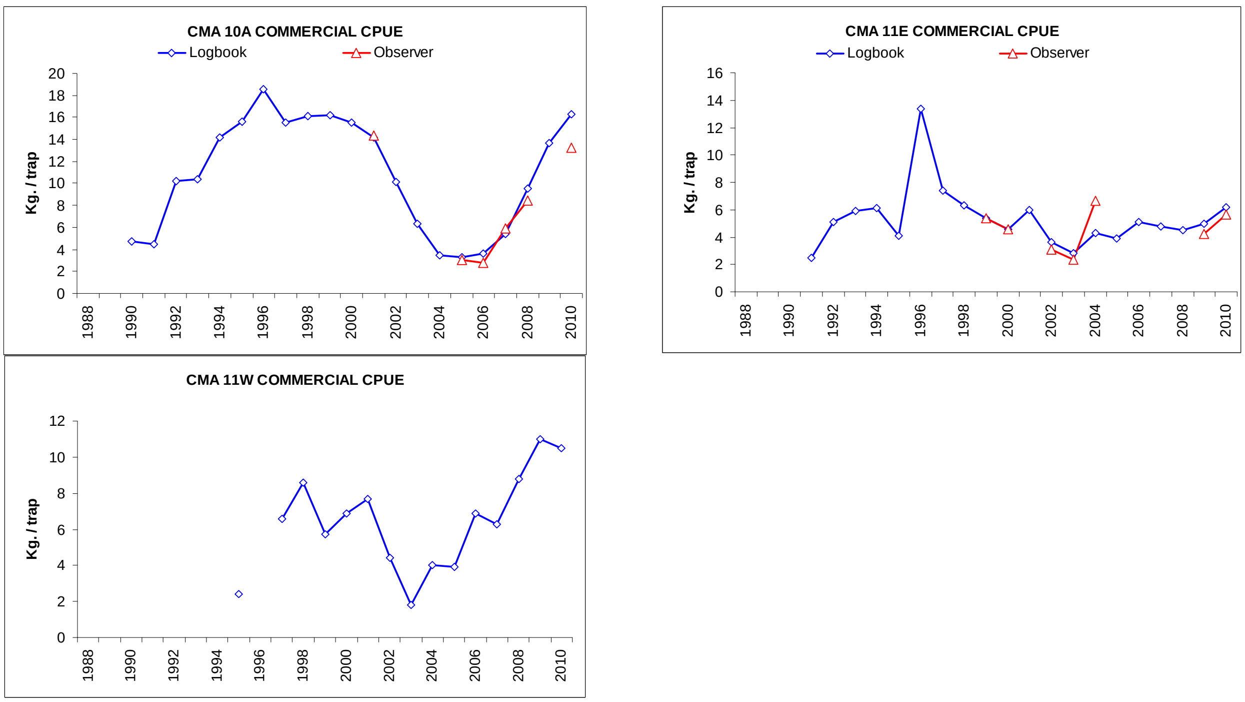


Figure 206: Trends in Subdivision 3Ps inshore logbook CPUE and observer CPUE by Crab Management Area.

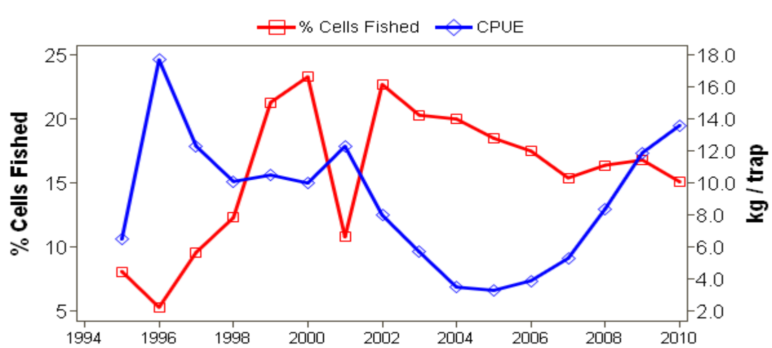


Figure 207: Trends in Subdivision 3Ps inshore logbook CPUE vs. the percentage of 5' x 5' cells fished.

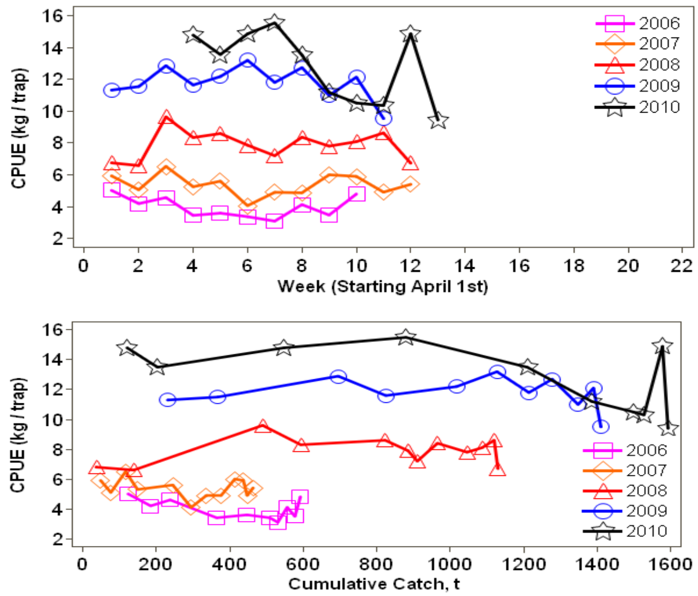


Figure 208: Seasonal trends in logbook-based CPUE for Subdiv. 3Ps inshore during 2006-2010; (above) by week, and (below) in relation to cumulative catch.

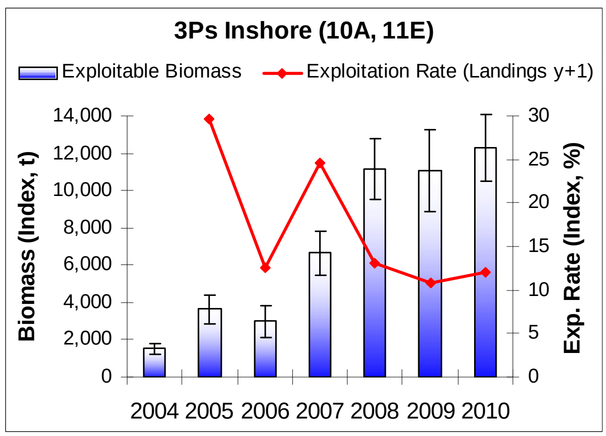


Figure 209: Exploitable biomass and exploitation rate indices from the CPS trap survey in Subdivision 3Ps inshore.

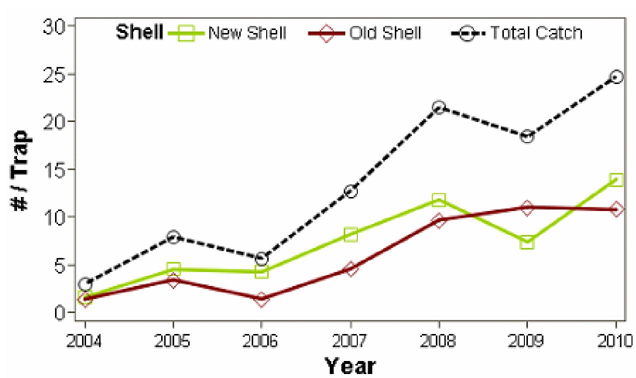


Figure 210: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Subdiv. 3Ps inshore.

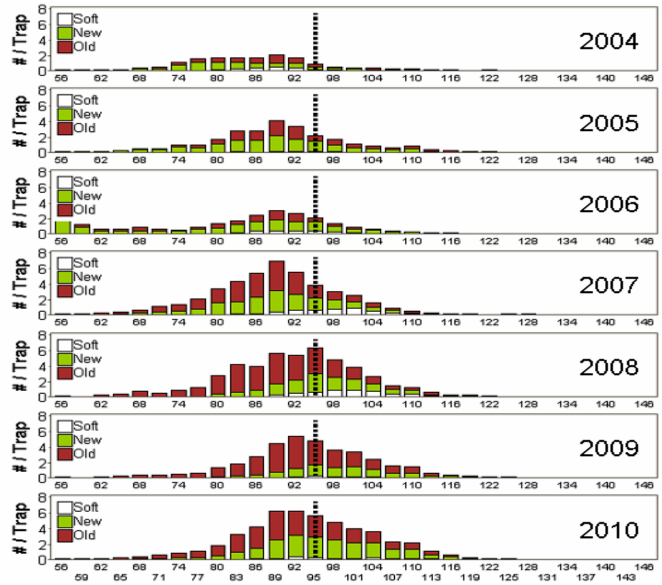


Figure 211: Trends in male carapace width distributions from core stations in the Subdiv. 3Ps inshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

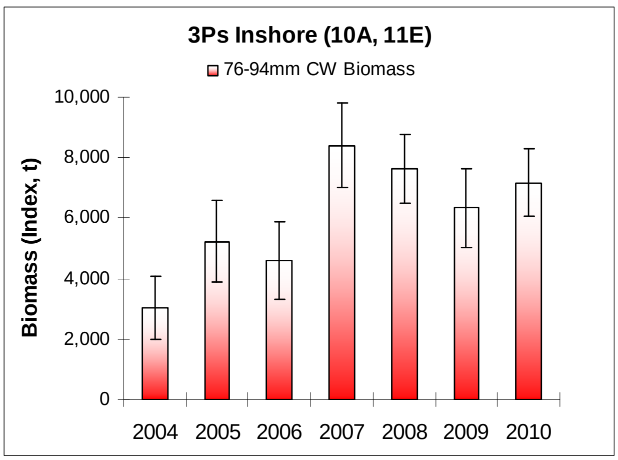


Figure 212: Pre-recruit biomass index based on the CPS trap survey in Subdiv. 3Ps inshore.

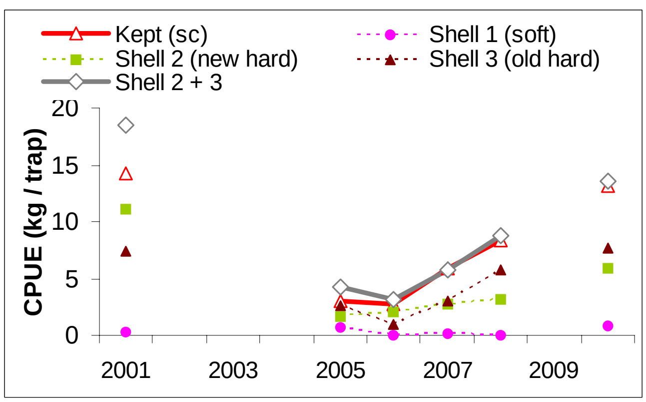


Figure 213: Trends in CMA 10A observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

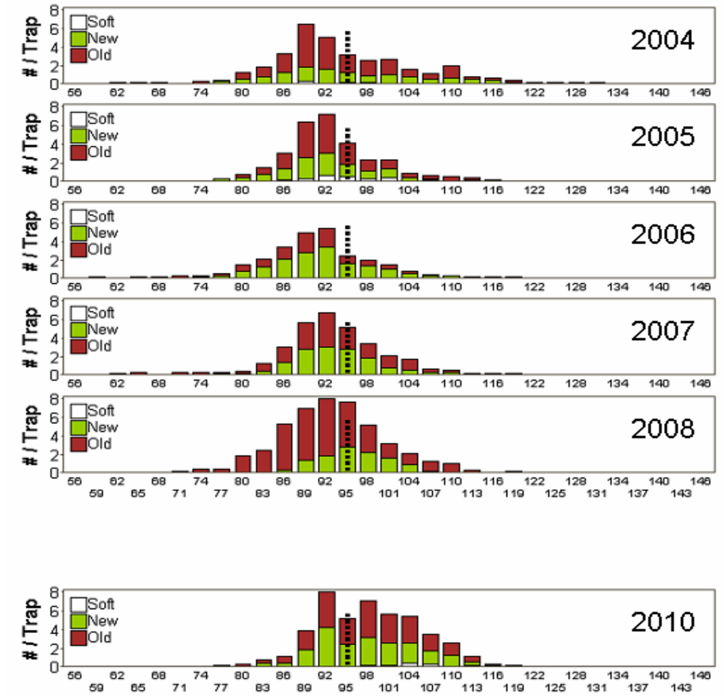


Figure 214: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 10A. The vertical dashed line indicates the minimum legal size.

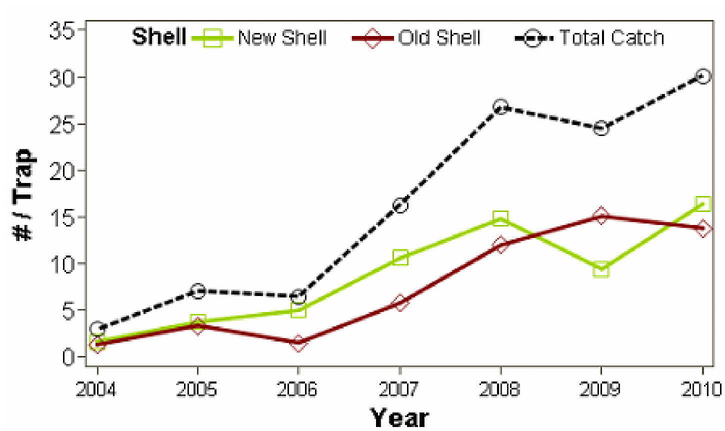


Figure 215: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 10A.

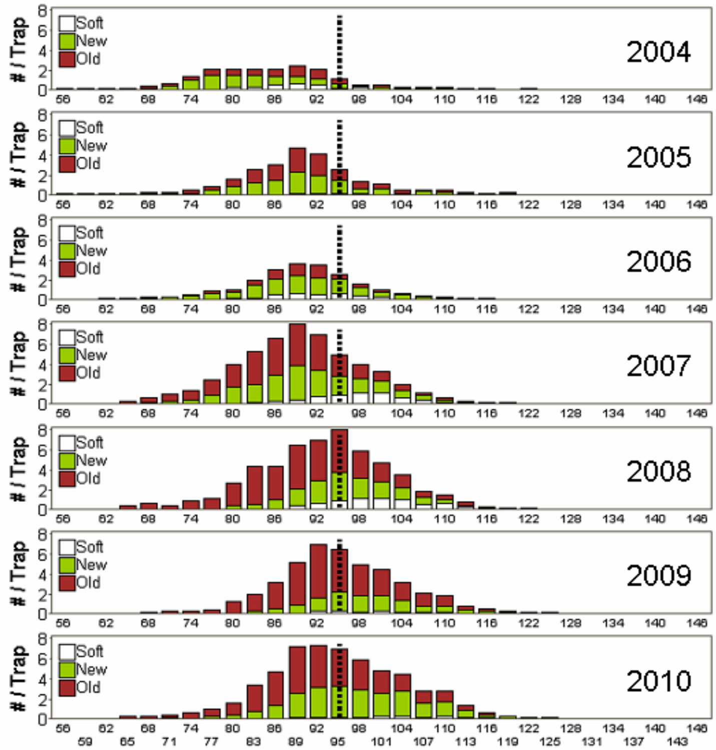


Figure 216: Trends in male carapace width distributions by shell condition from core stations in CMA 10A from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

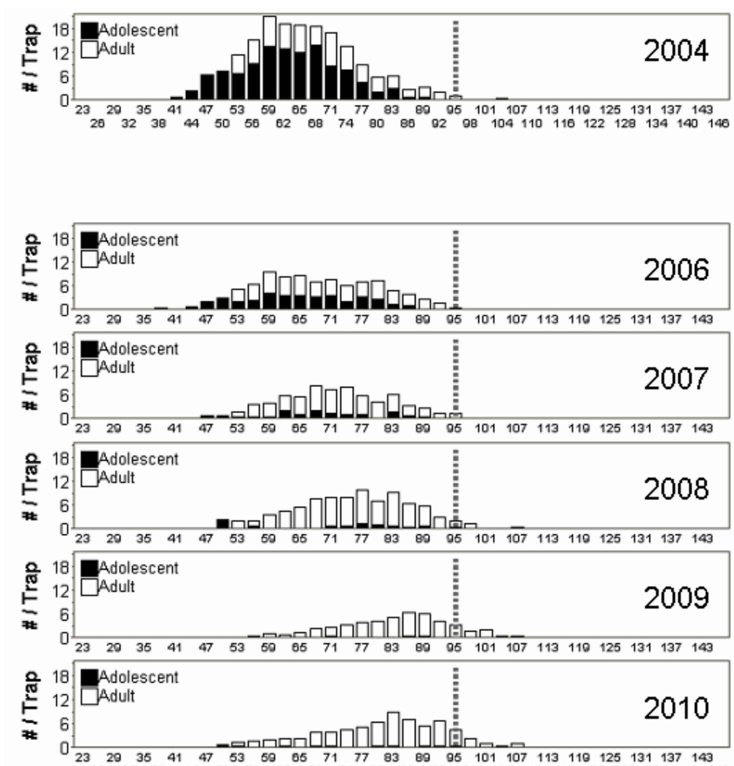


Figure 217: Trends in males carapace width distributions from small-mesh traps in CMA 10A from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

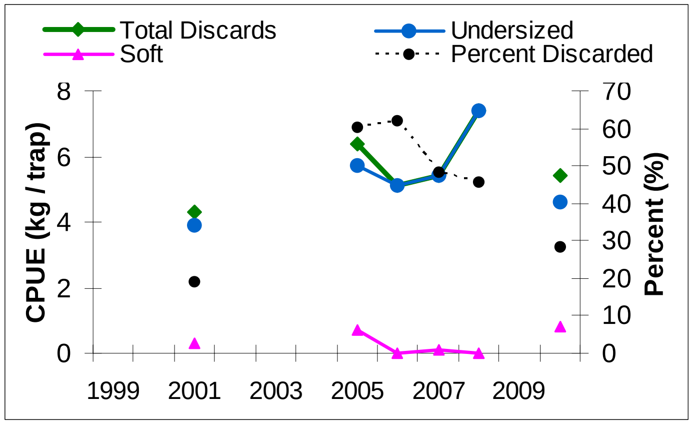


Figure 218: Trends in CMA 10A observer catch rates of total discards, undersized discards, and legal-sized discards, as well as the percentage of the catch discarded.

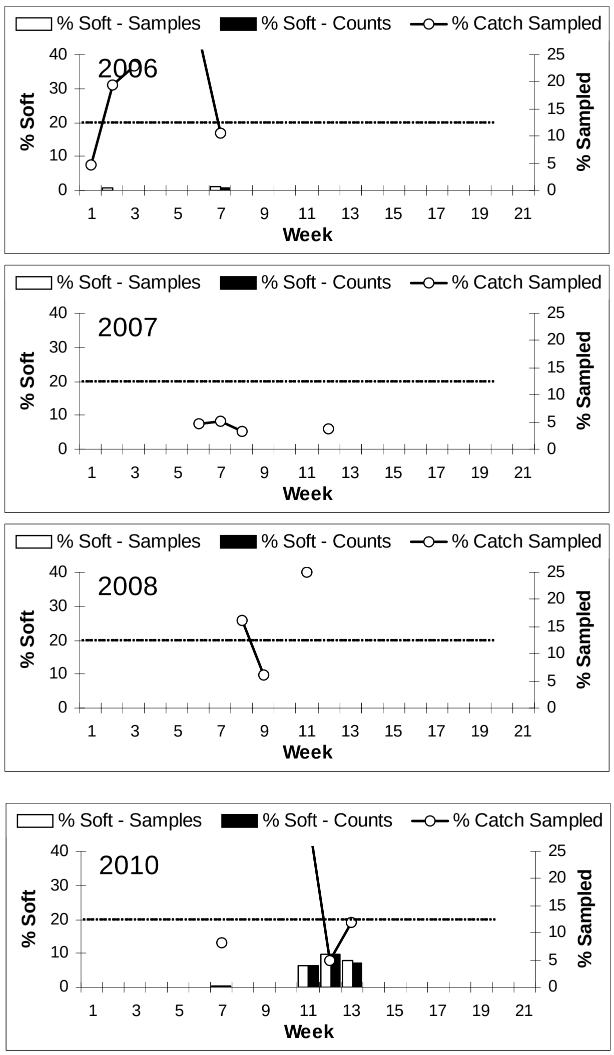


Figure 219: Trends in weekly percentages of soft-shell crab monitored and sampled in CMA 10A from 2006-2010.

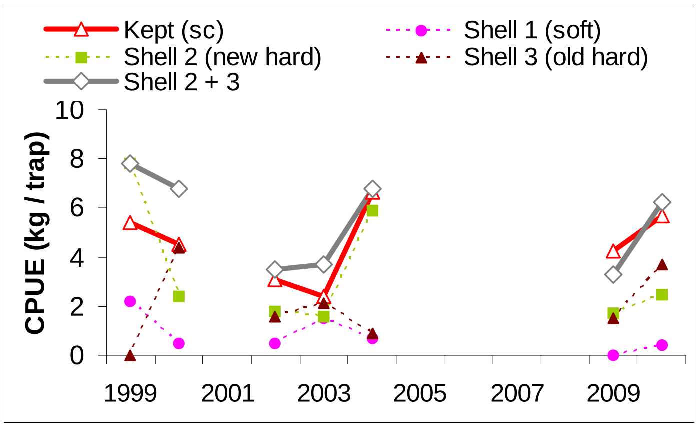


Figure 220: Trends in CMA 11E observer catch rates of exploitable crabs from set and catch records (kept) versus catch rates of sampled legal-sized crabs by shell condition category.

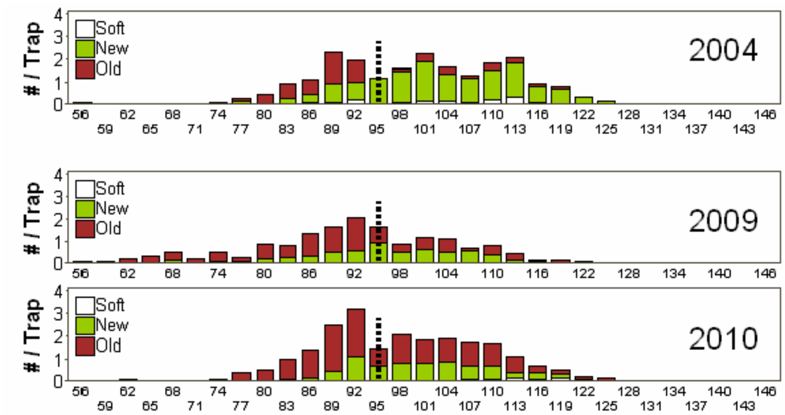


Figure 221: Trends in male carapace width distributions by shell condition from observer at-sea sampling for CMA 11E. The vertical dashed line indicates the minimum legal size.

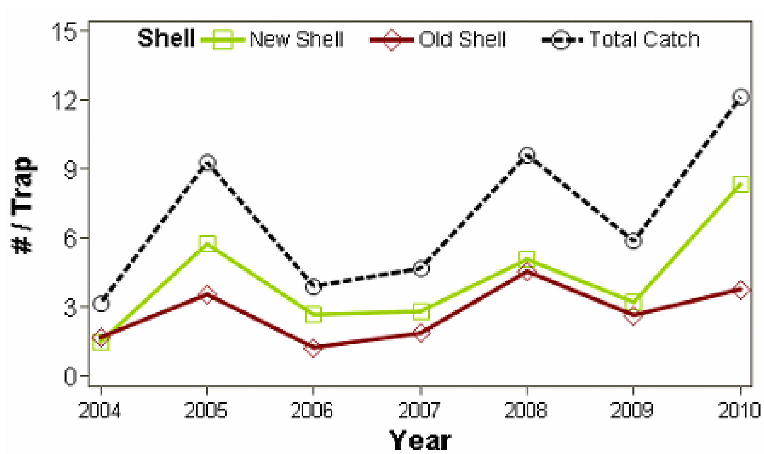


Figure 222: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 11E.

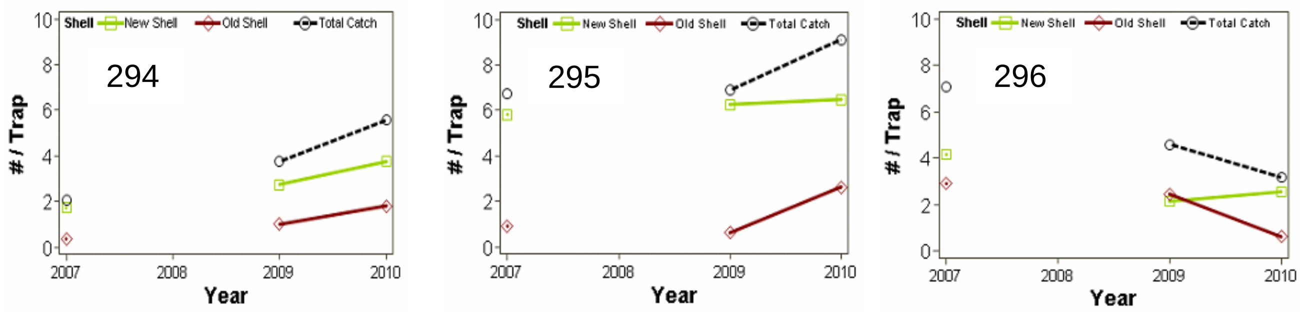


Figure 223: Trends in CPUE by shell condition for legal-sized crabs from the stratum occupied in the DFO trap survey in Fortune Bay.

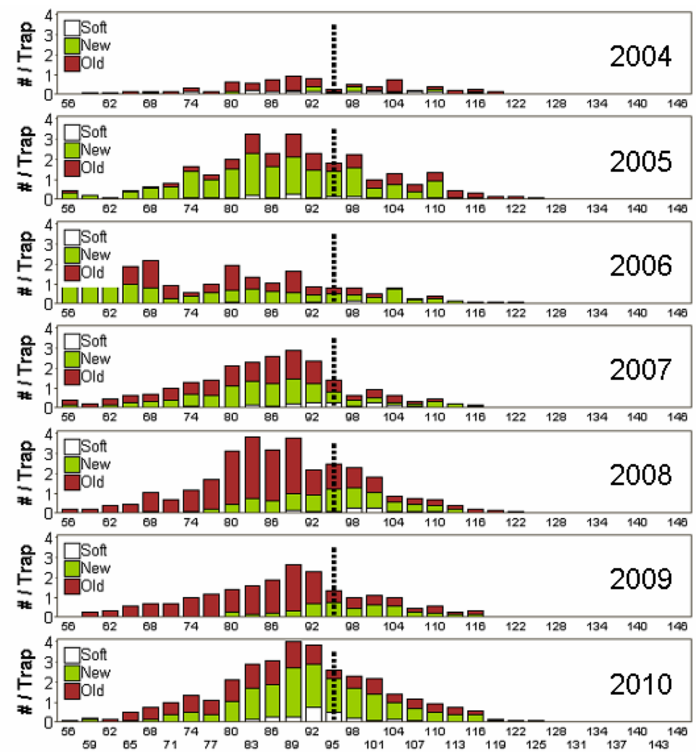


Figure 224: Trends in male carapace width distributions from core stations in CMA 11E from the CPS trap survey. The vertical dashed line represents the minimum legal size.

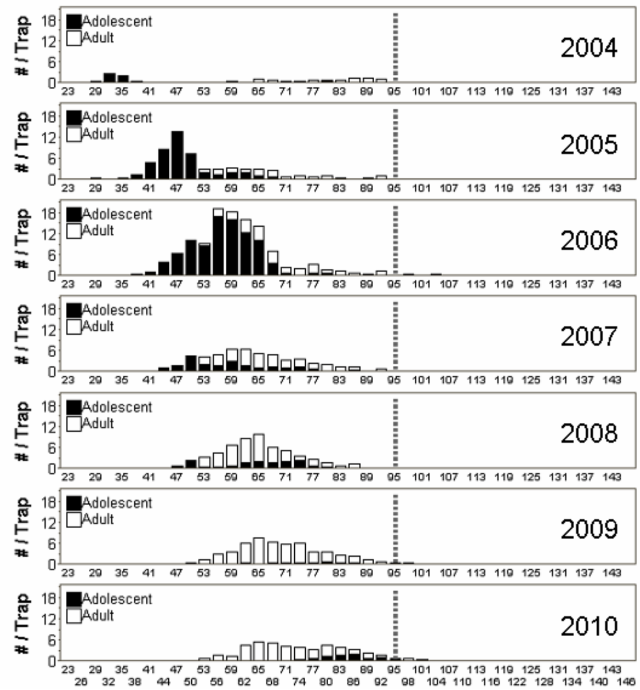


Figure 225: Trends in males carapace width distributions from small-mesh traps in CMA 11E from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

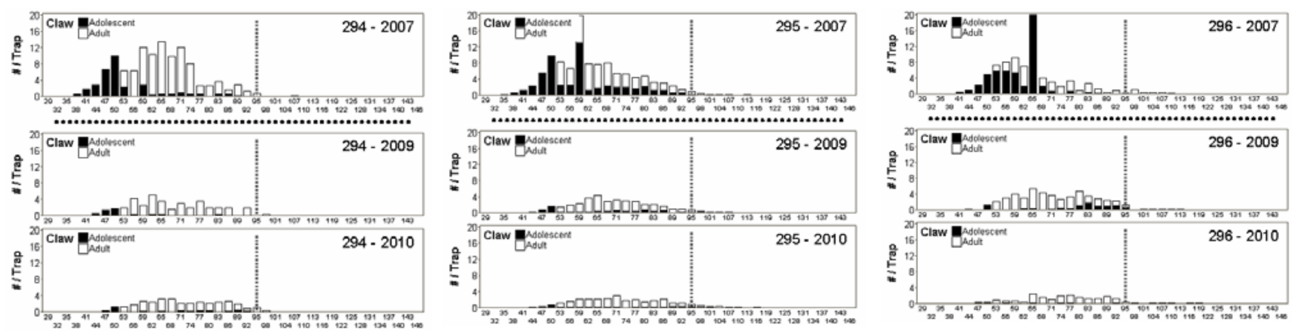


Figure 226: Small-claw (adolescent) vs. large-claw (adult) male catch rates by size from small-mesh traps in the stratum occupied in the DFO trap survey in Fortune Bay.

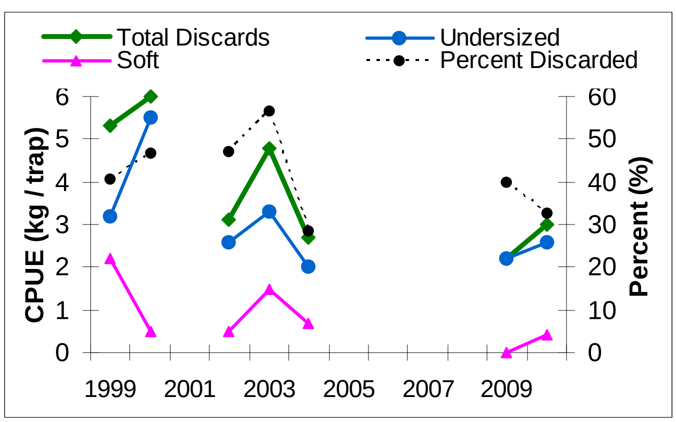


Figure 227: Trends in CMA 11E observer catch rates of total discards, undersized discards, and legal-sized discards, as well as the percentage of the catch discarded.

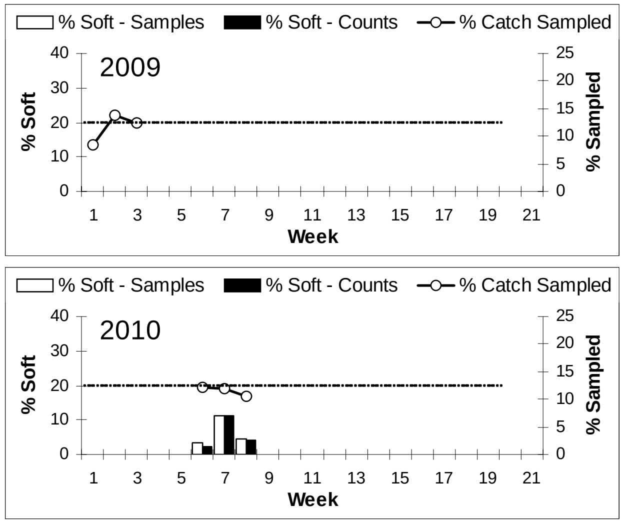


Figure 228: Trends in weekly percentages of soft-shell crab monitored and sampled in CMA 11E from 2009-2010.

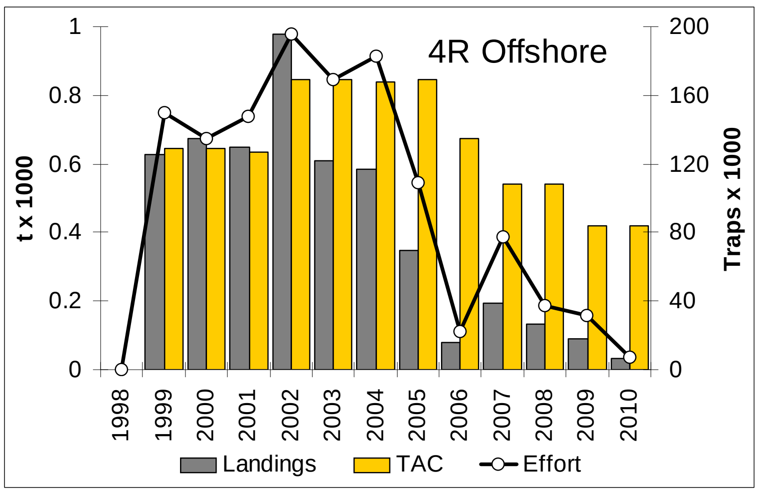


Figure 229: Trends in Div. 4R offshore landings, TAC, and fishing effort.

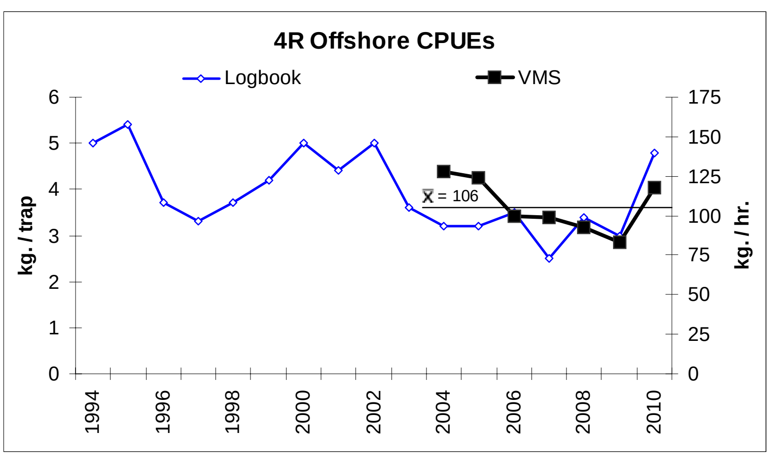


Figure 230: Trends in commercial logbook-based and VMS-based CPUE in the Subdiv. 3Ps offshore fishery. Solid black line denotes long-term VMS average.

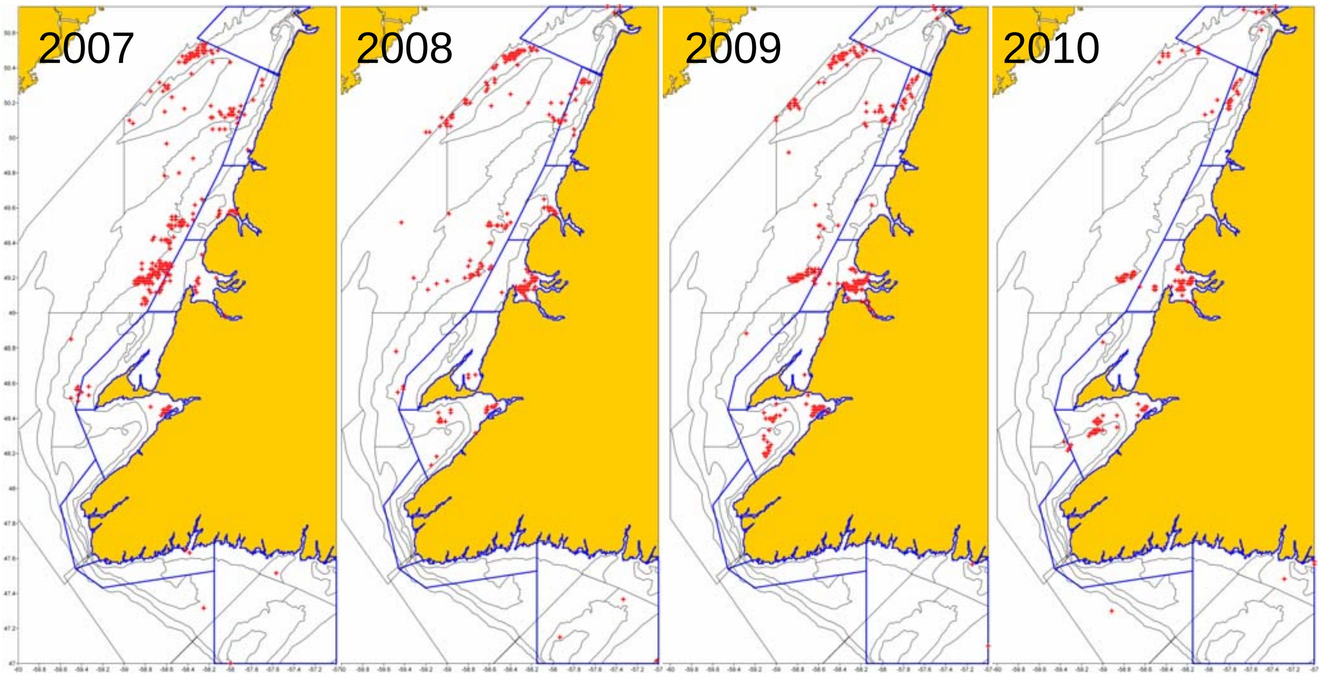


Figure 231: Spatial distribution of Div. 4R fishing effort by year.

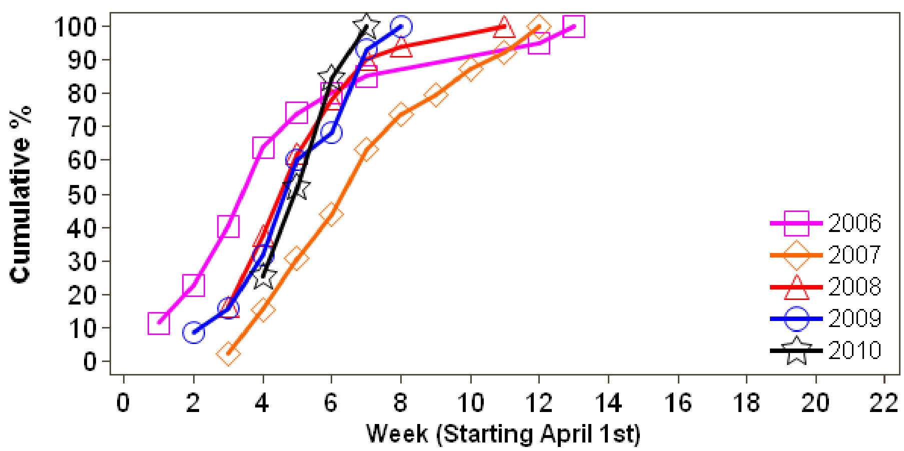


Figure 231: Seasonal trends in weekly fishing effort for Div. 4R during 2006-2010.

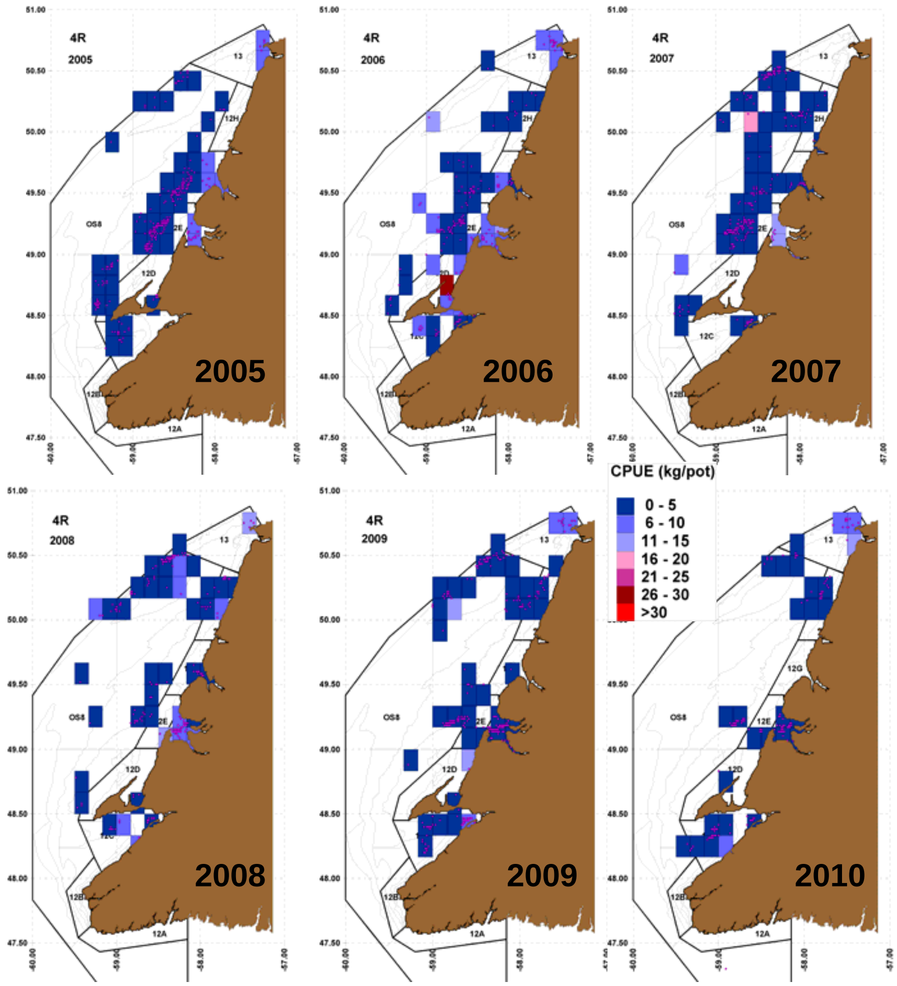


Figure 232: Spatial distribution of Div. 4R logbook CPUE by year.

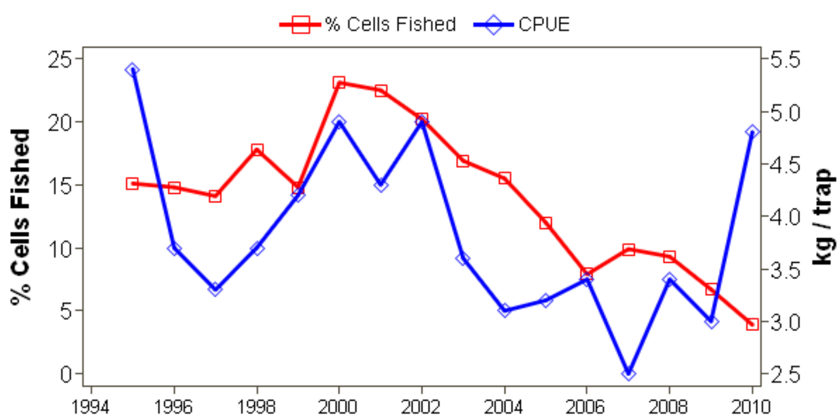


Figure 233: Trends in Div. 4R offshore commercial CPUE vs. the percentage of 5' x 5' cells fished.

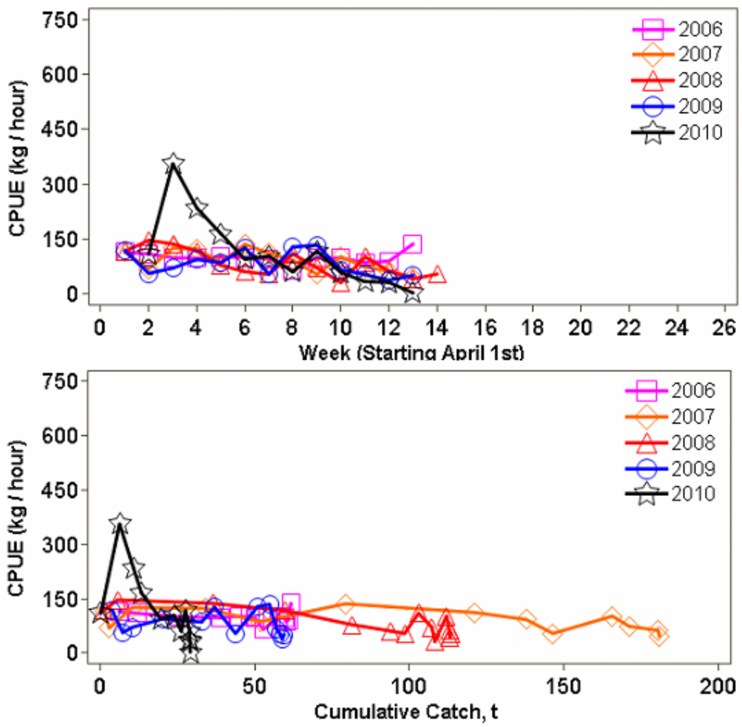


Figure 234: Seasonal trends in VMS-based CPUE for Div. 4R offshore during 2006-2010; (above) by week, and (below) in relation to cumulative catch.

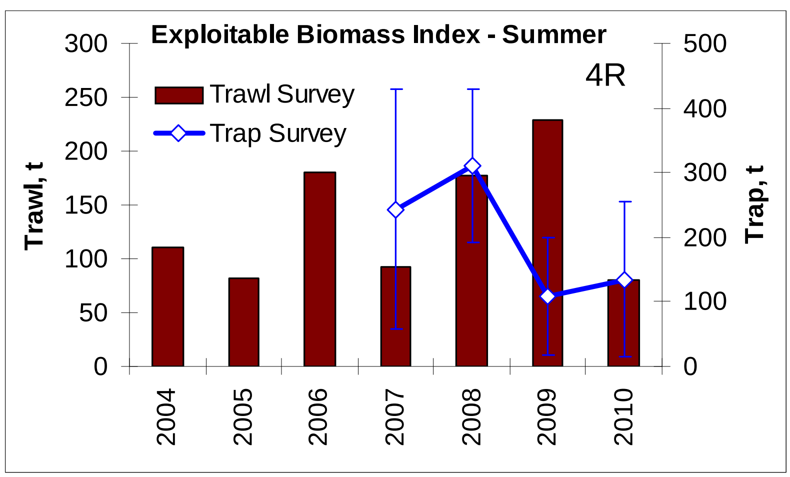


Figure 235: Trends in Div. 4R offshore summer trawl survey exploitable biomass index and the CPS trap survey biomass index.

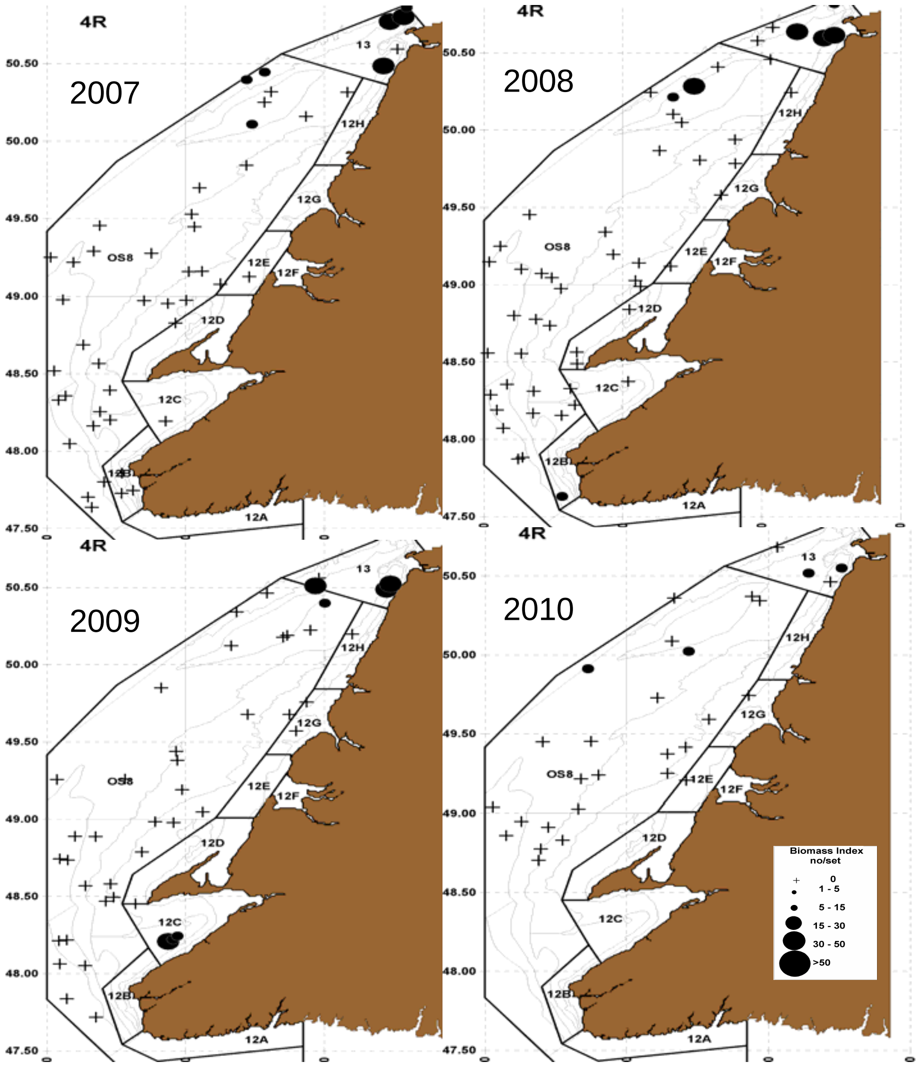


Figure 236: Spatial distribution of catches of legal-sized males in the Div. 4R summer trawl survey.

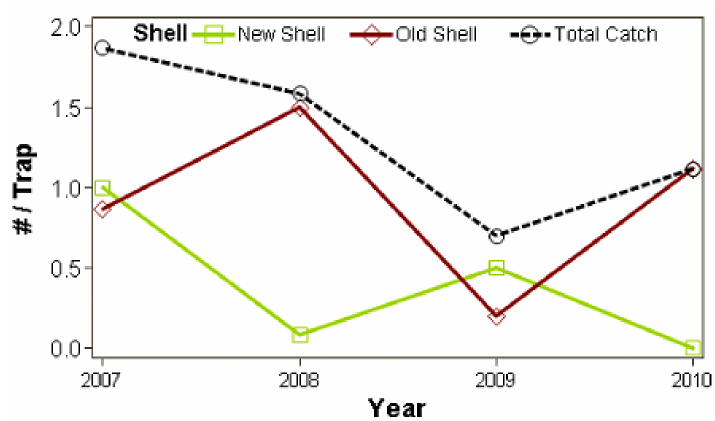


Figure 237: Trends in CPUE by shell condition for legal-sized crabs from core stations in the Div. 4R offshore CPS trap survey.

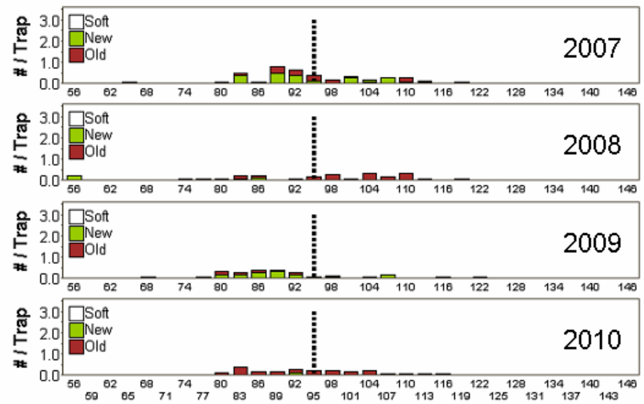


Figure 238: Trends in male carapace width distributions from core stations in the Div. 4R offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

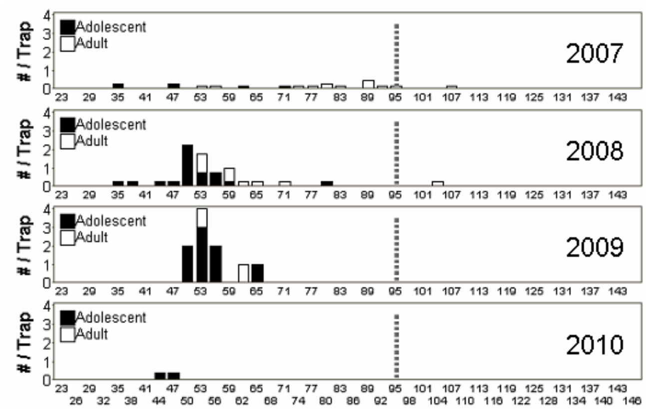


Figure 239: Trends in male carapace width distributions from small-mesh traps in the Div. 4R offshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

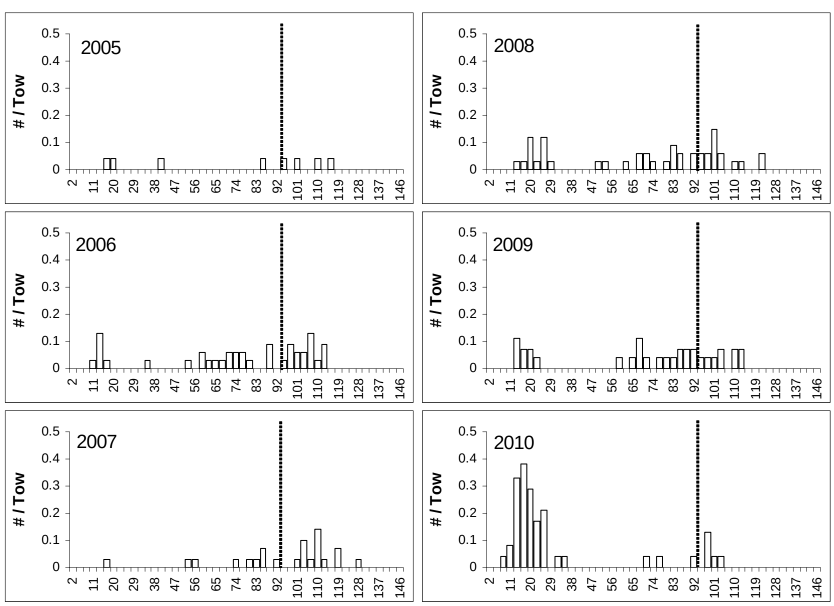


Figure 238: Trends in male carapace width distributions from the summer trawl survey in Div. 4R offshore. The vertical solid line indicates the minimum legal-size.

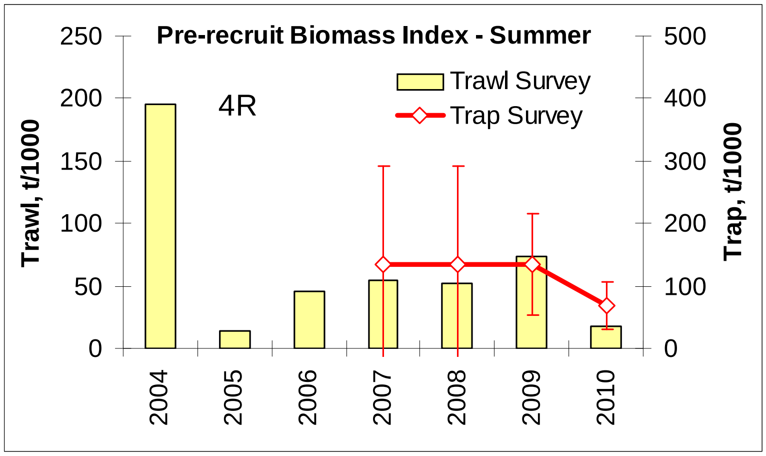


Figure 239: Trends in the Div. 4R trawl survey pre-recruit biomass index and the CPS trap survey biomass index.

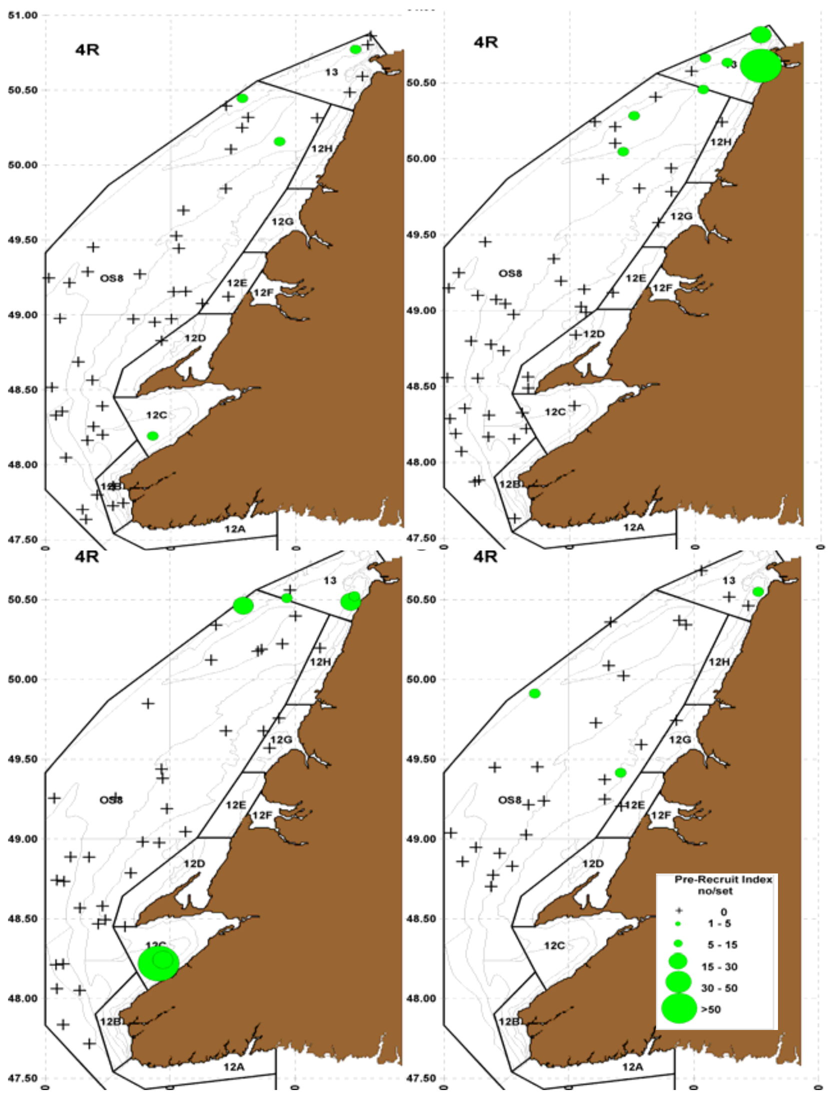


Figure 240: Spatial distribution of catches (number/set) of pre-recruit crab in the Div. 4R offshore trawl survey.

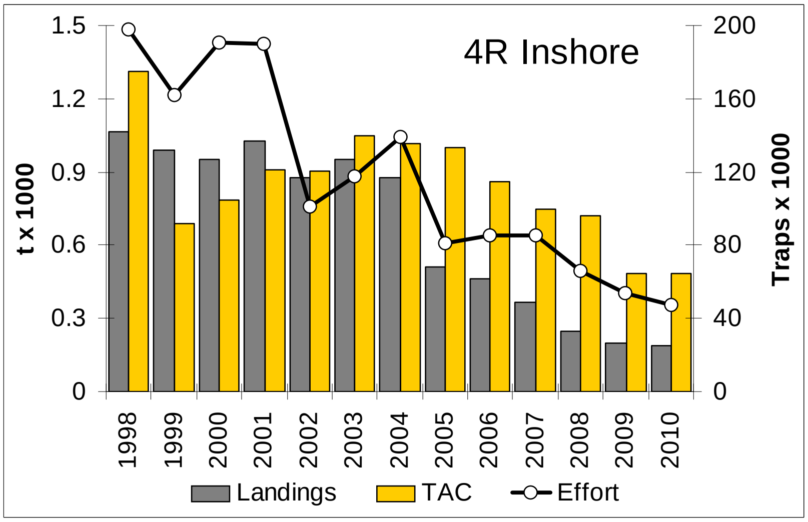


Figure 241: Trends in Div. 4R inshore landings, TAC, and fishing effort.

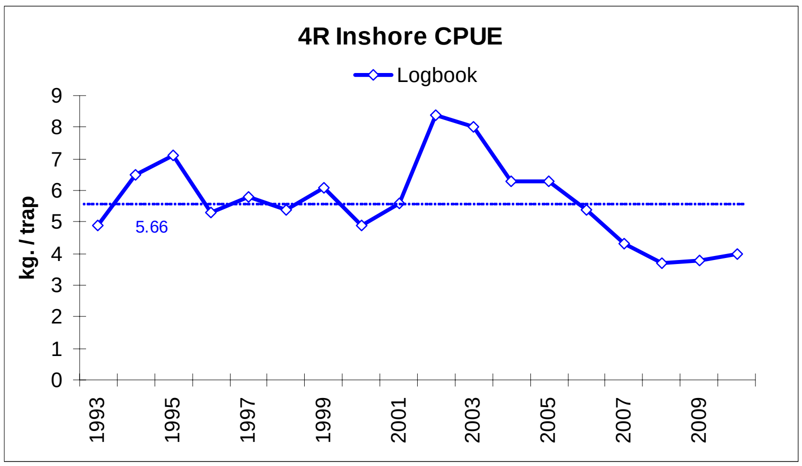


Figure 242: Trends in commercial logbook CPUE in the Div. 4R inshore fishery.

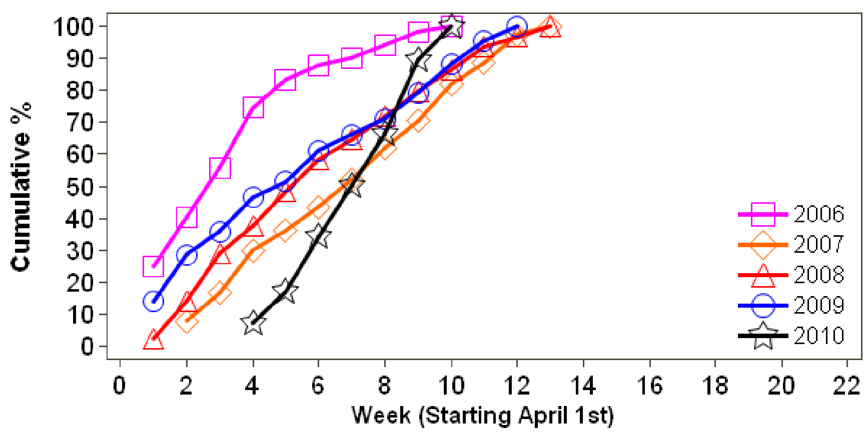


Figure 243: Seasonal trends in weekly fishing effort for Div. 4R inshore during 2006-2010.

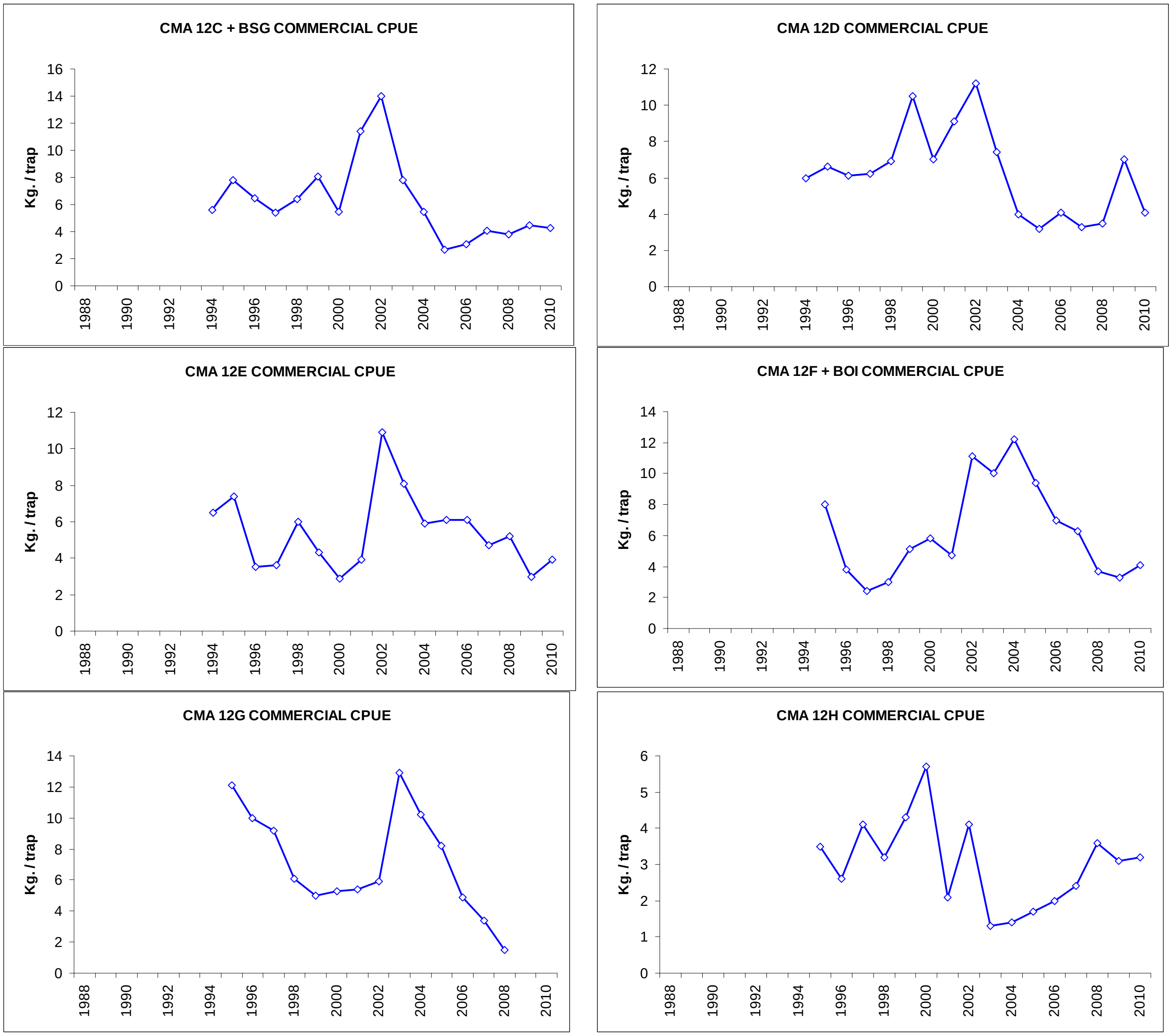


Figure 244: Trends in Division 4R inshore logbook CPUE by Crab Management Area.

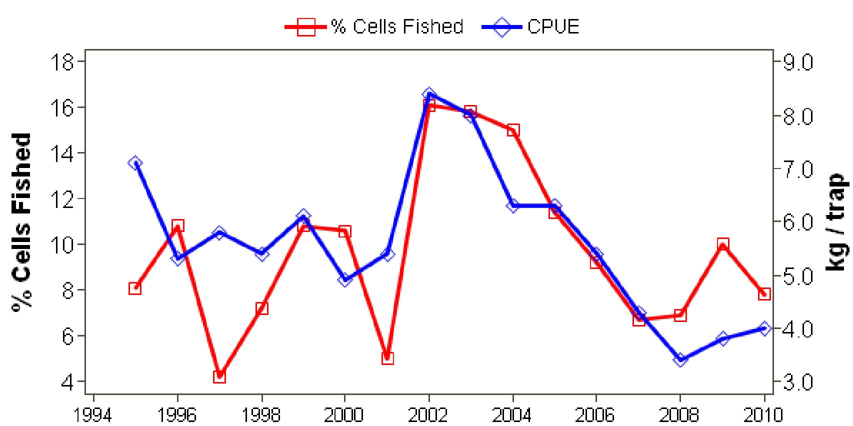


Figure 245: Trends in Division 4R inshore logbook CPUE vs the percentage of 5' x 5' cells fished.

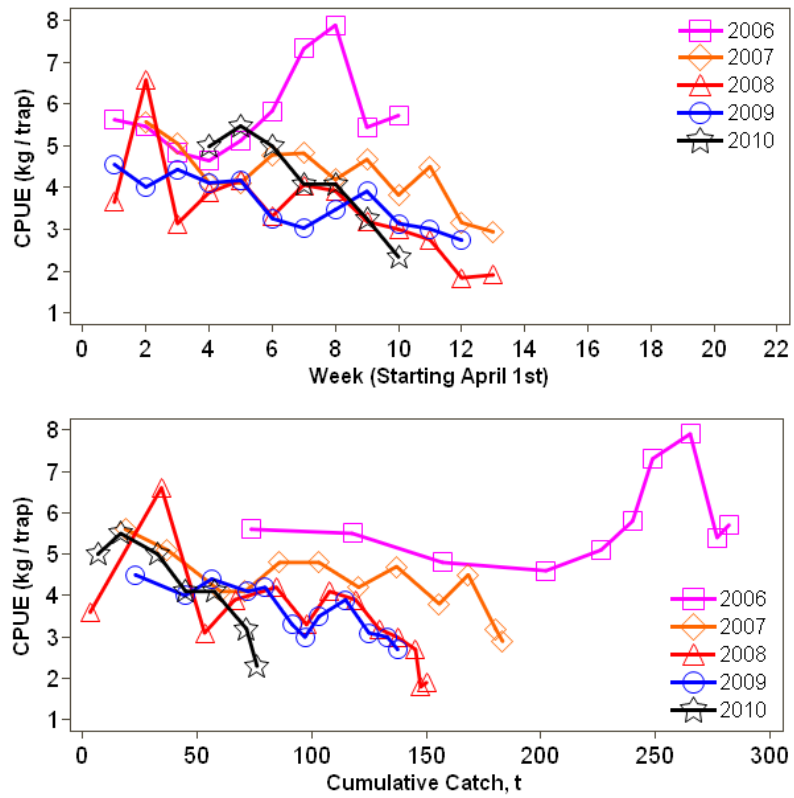


Figure 246: Trends in Division 4R inshore logbook CPUE vs the percentage of 5' x 5' cells fished.

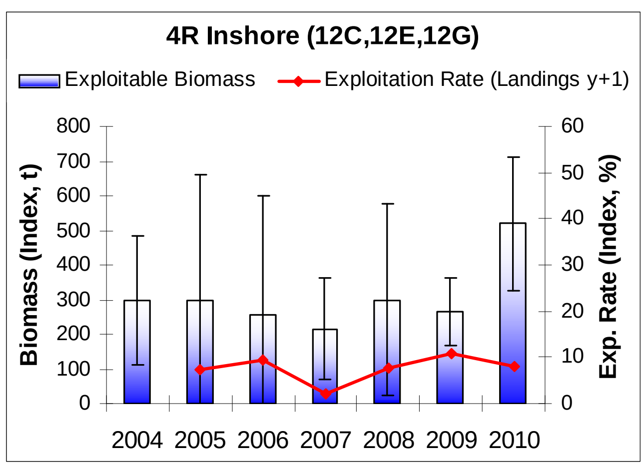


Figure 247: Exploitable biomass and exploitation rate indices from the CPS trap survey in Division 4R inshore.

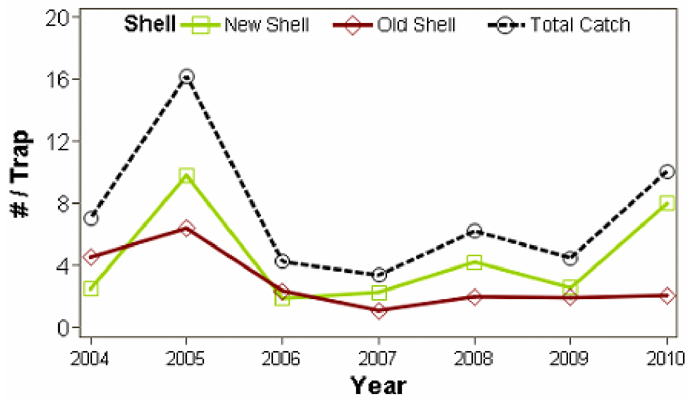


Figure 248: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in Division 4R inshore.

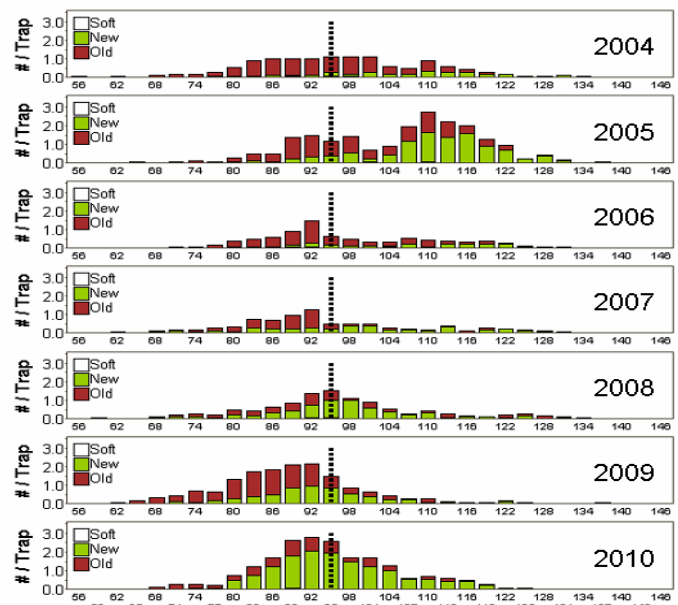


Figure 249: Trends in male carapace width distributions from core stations in the Division 4R inshore CPS trap survey. The vertical dashed line indicates the minimum legal size.

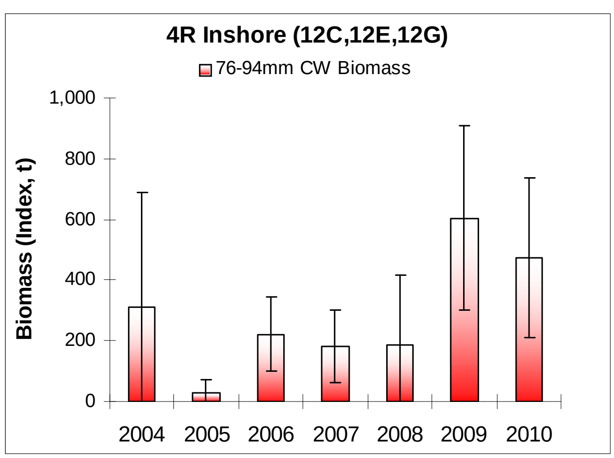


Figure 250: Pre-recruit biomass index based on the CPS trap survey in Division 4R inshore.

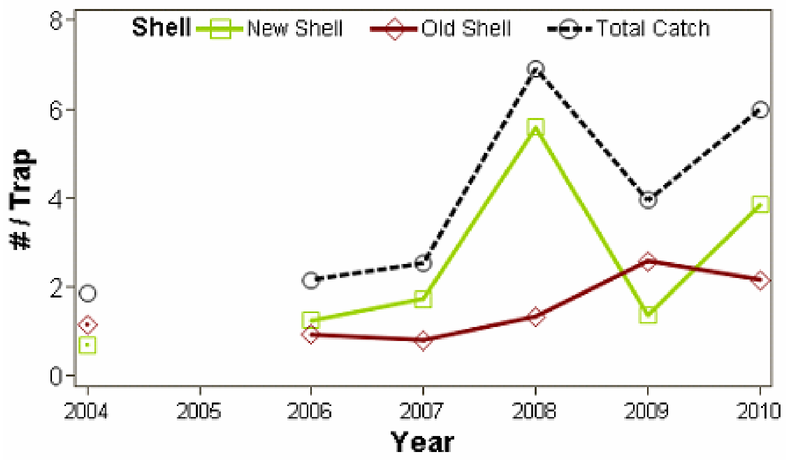


Figure 251: Trends in CPUE by shell condition for legal-sized crabs from core stations in the CPS trap survey in CMA 12C.

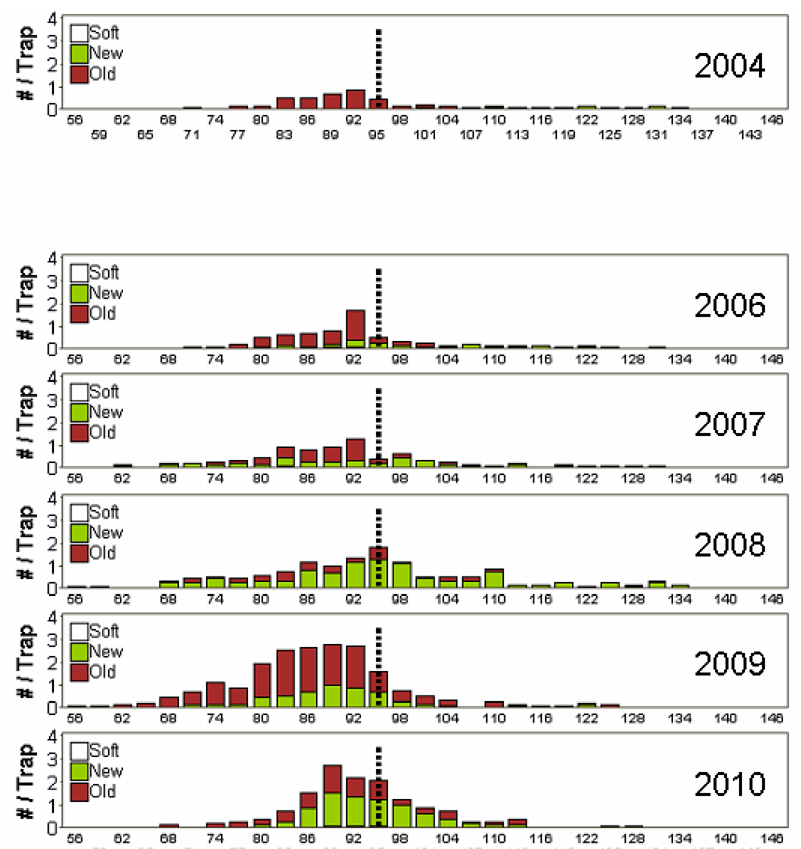


Figure 252: Trends in male carapace width distributions from core stations in the CMA 12C CPS trap survey. The vertical dashed line indicates the minimum legal size.

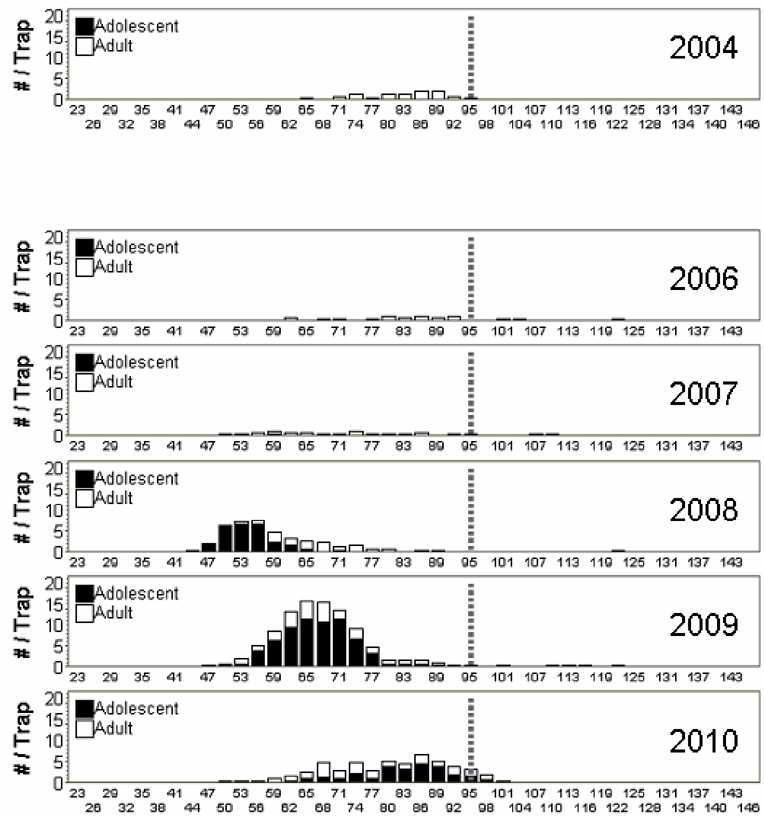


Figure 253: Trends in male carapace width distributions from small-mesh traps in CMA 12C from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

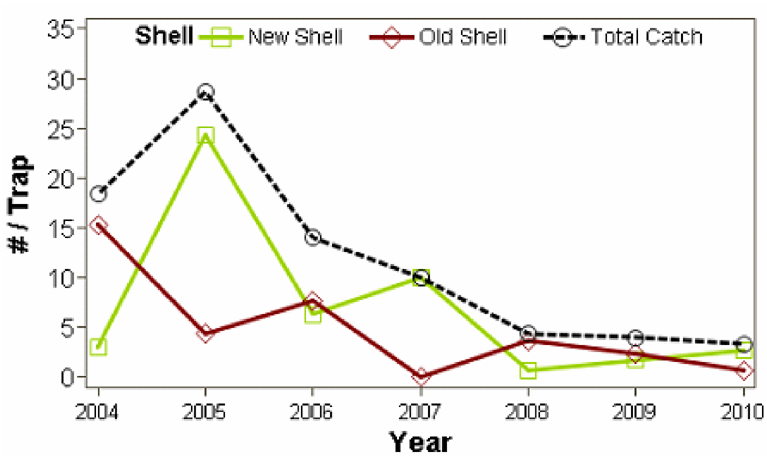


Figure 254: Trends in male carapace width distributions from core stations in the CMA 12E CPS trap survey. The vertical dashed line indicates the minimum legal size.

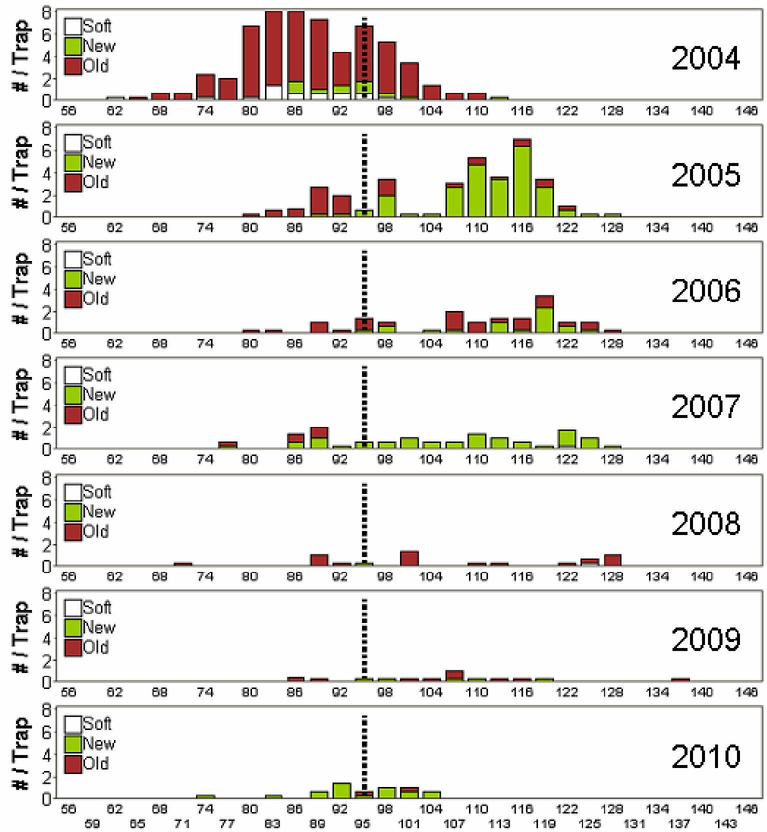


Figure 255: Trends in male carapace width distributions from core stations in the CMA 12E CPS trap survey. The vertical solid line indicates the minimum legal size.

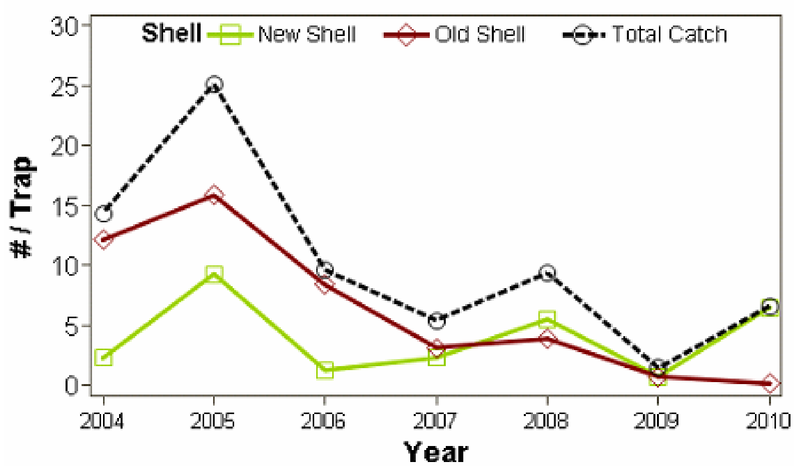


Figure 256: Trends in male carapace width distributions from core stations in the CMA 12F CPS trap survey. The vertical dashed line indicates the minimum legal size.

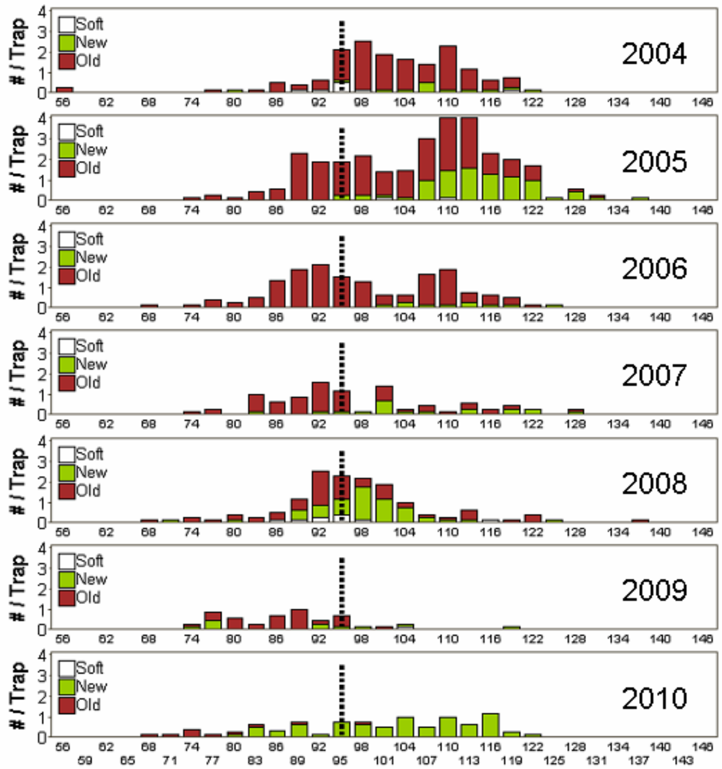


Figure 257: Trends in male carapace width distributions from core stations in the CMA 12F CPS trap survey. The vertical solid line indicates the minimum legal size.

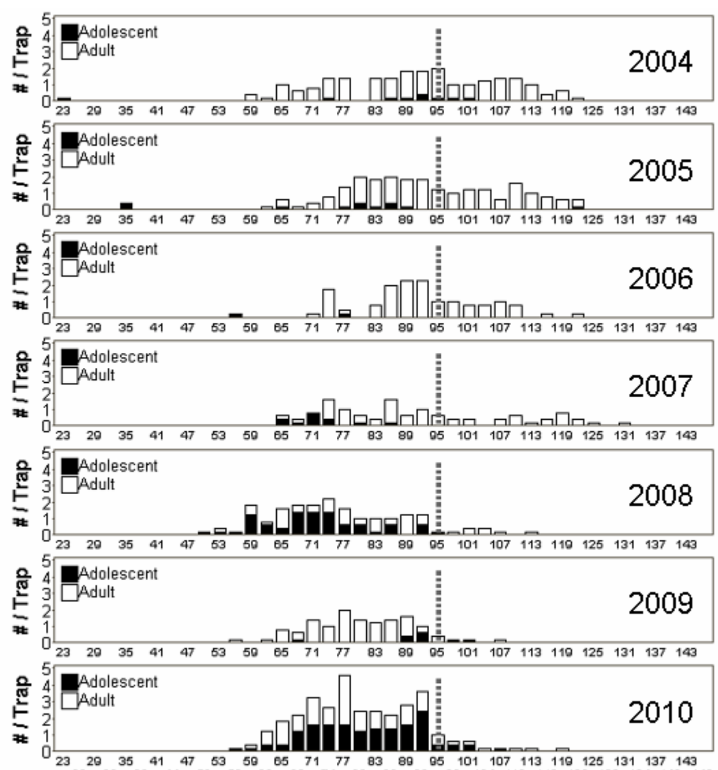


Figure 258: Trends in male carapace width distributions from small-mesh traps in CMA 12F from the CPS trap survey. The vertical dashed line indicates the minimum legal size.

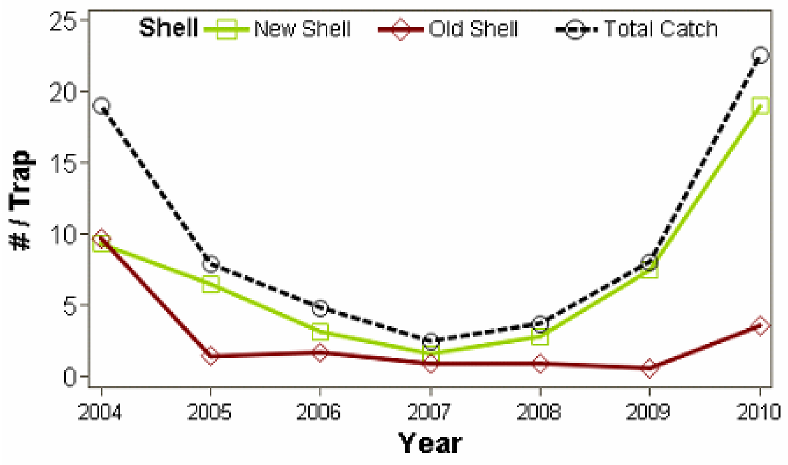


Figure 259: Trends in male carapace width distributions from core stations in the CMA 12G CPS trap survey. The vertical dashed line indicates the minimum legal size.

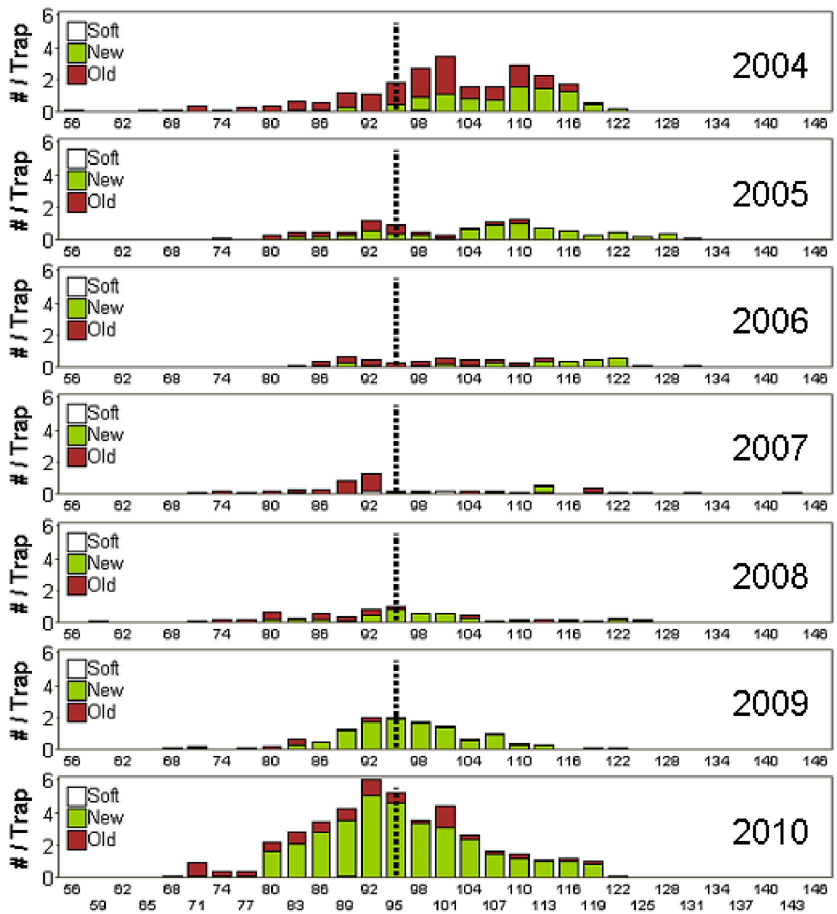


Figure 260: Trends in male carapace width distributions from core stations in the CMA 12G CPS trap survey. The vertical solid line indicates the minimum legal size.

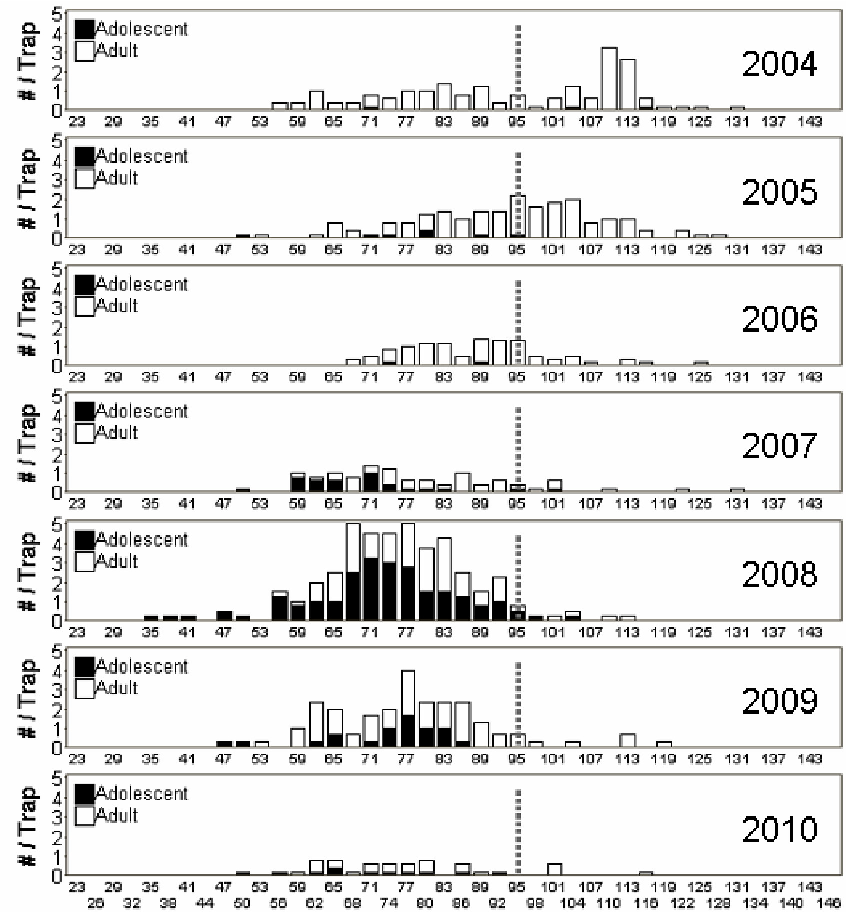


Figure 261: Trends in male carapace width distributions from small-mesh traps in CMA 12G from the CPS trap survey. The vertical dashed line indicates the minimum legal size.